INSTITUTES

OF

PHYSICS.

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PREFACE.

THE following Inſtitutes of Phyſics contain only the General Heads of an Annual Courſe of Lectures in the Univerſity of Glaſgow, together with Concluſions which reſult from Experiments performed at the ſame time.

In this manner, it ſeems proper to guard againſt the inaccuracies into which young Students are apt to fall, while the publication of more than ſuch Outlines might lead them to lay aſide the cuſtom of taking notes; a cuſtom, by which their attention and ingenuity are conſtantly exerciſed, and the Lectures and Experiments become, as it were, their own.

The concluſions from the experiments are expreſſed in the ſynthetic form of propoſitions and corollaries; ſo that every propoſition is like an enunciation in Euclid, and the experiments are exhibited as the proof. Some of the propoſitions, however, are ſo univerſally admitted as to render an experimental proof unneceſſary; and ſome of the experiments cannot be made at a public lecture, in which caſe the evidence of their truth, the neceſſary apparatus, and the method of uſing it, are minutely deſcribed, and nothing more can be done.

As technical terms ſave the trouble of repeating definitions, they are to be found not only in every ſcience, but in the loweſt mechanic arts. In Natural Philoſophy they are not very numerous, and their meaning is generally known; but there is an inaccuracy in the great diviſions of this ſcience, which occaſions the following remarks.

In the ſyſtems that are commonly uſed, Matter and its general properties are firſt conſidered; and then the attraction of Coheſion, Magnetiſm, Electricity, and Gravitation: Under Magnetiſm, the attraction and repulſion of the Magnet is explained: Under Electricity, the repulſive as well as the attractive phenomena of Electric Matter: And under Gravitation, both centripetal and centrifugal forces. But there is no term to denote that branch of Phyſics under which the general properties of Matter are conſidered, together with the attraction and repulſion of its minute parts. Atomology, though an ancient word, would be improper, becauſe of the ideas that are conveyed by it, and becauſe of the doctrines that were maintained by the Atomical Sect. Almoſt all the terms of art in Phyſics are borrowed from the Greeks. Somation had the ſame meaning with them, that Corpuſcle has with us. It therefore is uſed as the title of the firſt part, ſo that we are freed from the ſoleciſm of conſidering corpuſcular repulſion as belonging to the attraction of coheſion, and from the abſurdity of having a technical term for every part of Phyſics excepting the firſt.

Matter being the object of Phyſics, after a general explication of its nature is given, the next inquiry is, whether all bodies, or maſſes of matter, have the ſame qualities belonging to them. The ſlighteſt obſervation ſhews that they have not; and it becomes neceſſary to arrange them, if we would know them with certainty and eaſe. Accordingly they are reduced to ſeven Claſſes, and without the detail which Chemiſtry requires. Thus, it is not only proper to uſe the word Somatiology, but alſo to comprehend under it the general arrangement of bodies, corpuſcular attraction and repulſion, fire, and other corpuſcular phenomena; becauſe, if they are not explained, it is impoſſible to underſtand ſome of the moſt common reaſonings, and common inſtruments, which belong to the undoubted branches of Natural Philoſophy in the moſt reſtricted ſenſe. In this arrangement, Matter of every kind is claſſed without regard to the different forms in which it is found: And the claſſes, orders, diviſions, and ſubdiviſions, of which it conſiſts, cannot be reduced to a ſmaller number; without giving up preciſion in arrangement, or aſcribing qualities to bodies which our preſent experiments do not fully ſupport.

After conſidering the properties of Matter enumerated in the firſt part, there are others of a different kind, which make the objects of the ſecond, third, and fourth. Equivalent terms to Foſſils, Vegetables, and Animals are to be found in every language. This ſhews that theſe are obvious claſſes of Matter. When ſpeculative men compared the Univerſe to the Roman Empire which contained many kingdoms, they conſidered theſe claſſes as three kingdoms in the Material Empire of God: And as it was the buſineſs of Civil Hiſtory to deſcribe political bodies and their changes, ſo it became the buſineſs of Natural Hiſtory to deſcribe Natural Bodies, or Minerals, Vegetables, and Animals, together with the changes to which they are ſubject by the laws of nature, in oppoſition to the operations of art.

The arrangement of Foſſils is according to the claſſes, orders, and genera in Somatiology; and to the genera are added the ſpecies, according to their external marks. This Method is ſimple and fixed; while others not ſimilar to it have been varied, and may be varied without end. The doctrine of elementary particles is one of the moſt ancient in Philoſophy, and yet it is only of late that attempts have been made to arrange Foſſils according to the elements which they contain. The common Method has been to claſs them according to their Uſes, or external appearances; which is inaccurate and tedious, becauſe Uſes are variable, and a multitude of external marks is neceſſary to diſtinguiſh the greateſt part; as ſome have the ſame properties with different appearances, and others the ſame appearances with different properties. In courteſy, however, to common Methods, the moſt noted of the figured ſtones are mentioned; to enumerate them all would be as difficult and as uſeleſs as to arrange the clouds.

In order to remove the objections of a very eminent author, and of others who follow his Method, it may be proper to obſerve, that the Saxa and Mineralia Larvata cannot be excluded from a ſcientific arrangement; for what ſhould we think of a ſyſtem in any other branch of knowledge that required an appendix? Though Scoriae, therefore, are bodies, which are in a different ſtate from what they once were; though wood and ſome moulds belong to the vegetable kingdom, and ſhells and other bodies dug out of the earth, to the animal kingdom; yet the changes they have undergone were not produced by art; and therefore, they are Foſſils in the juſteſt ſenſe. It muſt be remembered likewiſe, that there are few Foſſils which are not compounds; and conſequently, that they may be placed in different claſſes according to the parts of which they are compoſed. To repeat them in every claſs to which ſome of their parts belong, would be a troubleſome and uſeleſs taſk; but ſuch as are very heterogeneous are repeated with an Aſteriſk, which ſhews that they may have different places, while the general principles of the ſyſtem may be preſerved.

Vegetables and Animals exceed Foſſils to an extent of variety and number that is prodigious; but ſexual differences and fixed external marks render it eaſier to claſs the ſecond and third than the firſt of the Kingdoms of Nature. Botany belongs not to the author's province. It is obvious, however, that the general laws of every part of the material world belong to Phyſics; and that it is only by the facts eſtabliſhed in Somatiology, that the true principles of Botany can be explained. One may underſtand the nature of a political ſyſtem, without knowing the names of the perſons of which it is compoſed.

Some Zoologiſts content themſelves with diffuſe and indeterminate deſcriptions, ſo that their Methods are as little ſcientific as that of the Mineralogiſts above-mentioned. Others imagine, that all claſſing is as arbitrary as the whimſical arrangement which any one may give to the particles in a heap of ſand; not conſidering that anatomical marks fix the claſſes in Zoology, with as much certainty, as ſecondary particles do in Mineralogy; and that when theſe cannot be got, the mode of living, or the want of progeny, furniſhes others that are equally diſtinct. A third ſort aim little at ſcientific marks, which ought always to be the great object in Philoſophy, but change arrangements in order to make them more elegant, or more natural in their opinion; not obſerving that all who do ſo, in any of the three Kingdoms of Nature, ought to be viewed in the ſame light with that Librarian who boaſted of having done great ſervice to learning; becauſe he had changed the places of his books. A fourth ſort, while they deſerve much praiſe in other reſpects, uſe ſmall, great, long, ſhort, &c. in their deſcriptions; though theſe terms relate to things which they do not define, and therefore, the characters upon which they reſt are inaccurate. On the other hand, from a love of ſyſtem, they ſometimes conjoin the moſt heterogeneous animals; not conſidering, that the obvious diſtinctions in the material world are often as ſcientific as the concealed.

To theſe remarks two may be added. The firſt is, That though the maxim be true, "Nil per ſaltum "facit natura," yet when endleſs gradations would produce confuſion in Natural Hiſtory, the Author of Nature has ſaid to that part of his works, as well as to the ſea, "Hitherto ſhalt thou come, and no far-"ther." So that Blind Fate, Equivocal Generation, and Unlimited Combinations are doctrines that are perfectly abſurd. The ſecond is, That the chief deſign of Lectures of this ſort ought to be to fix ſcientific characters with preciſion, to point out the marks of benignity and wiſdom which are in the Creation, and to explain thoſe objects of Natural Hiſtory which contribute to the happineſs of individuals, or to the proſperity of nations.

After Natural Hiſtory, the next general diviſions of Phyſics are Electricity and Magnetiſm. The Etymology and objects of both are well known. But ſome diſtinguiſhed writers employ the firſt in an improper ſenſe; for they denote by it not only the name of the Science, but alſo the Cauſe which produces the effects. In the firſt ſenſe alone it ought to be uſed: for to give the ſame name to things that are different, can never be juſtified; unleſs it is the deſign of the writer to be miſunderſtood. It would be well if this were the only term in Philoſophy to which this remark might be applied.

The power of Gravity near the ſurface of the earth is the ſubject of the ſeventh Part. Whether it extends to remote diſtances cannot be examined till the laws of Central Forces are known, which is a part of Mechanics; and till the laws of the Heavenly Bodies are known, which is the object of Aſtronomy.

Some have thought that one Attractive and Repulſive Power, or even one Attractive Power differently modified, may produce all the phenomena which are enumerated in theſe parts of Phyſics.

But this is ſuppoſed, not proved; and, therefore, ſince the phenomena are different, theſe diviſions ought to be preſerved. A ſimilar remark may be made concerning the Claſſes of Matter with their diviſions; for no advantage can ariſe to Philoſophy from a diminution of the number of principles while they are doubtful; nor to Students while the phenomena are different. And as to terms expreſſive of new opinions, he muſt be little acquainted with Natural Hiſtory, or with Medicine, who does not know that theoretic names were always uſeleſs, and often hurtful to ſcience.

It is difficult, and ſometimes impoſſible, to find Engliſh words which correſpond exactly with all the learned terms in common uſe. It is convenient for a Student to be made acquainted with ſuch as are to be found in ſtandard authors, and a variety of them is ſometimes uſed for that very purpoſe. Theſe Reaſons, it is hoped, will be a good apology for mixing together the terms of different languages, of common life, and of Philoſophy. Some writers ſeem to be as fond of making new names, as if they deſerved praiſe for increaſing the diſagreeable part of ſcience; or as if there were ſome merit in giving different arrangements to letters and ſounds. So much care has been taken to avoid this practice, that there are but two or three entire new words in this volume. They were unavoidable, and their meaning is obvious.

Mechanics, Hydroſtatics, and Pneumatics make the eighth, ninth, and tenth diviſions in this Syſtem.

Under the firſt, ſome authors comprehend Gravitation, and others Aſtronomy, and even Hydroſtatics, and Pneumatics. In this volume, the object of Mechanics is reſtricted to the laws of ſolids when acting with different coheſions, velocities, and forms.

By Hydroſtatics, the ancients meant the laws of water when at reſt; and by Hydraulics, the laws of water when in motion. Many of the moderns include both under the firſt, which is likewiſe done in this volume, but the ancient diſtinction is marked out by a ſubdiviſion in the general arrangement.

The object of Pneumatics is that Elaſtic Fluid which ſurrounds the earth, and which is neceſſary to preſerve animal life, vegetable life, and flame; but as part of it is conſtantly loſing this intereſting quality, it becomes neceſſary to know how this loſs is effected, and how it is reſtored. Pneumatics, accordingly, has two great diviſions; the firſt of Common Air, and the ſecond of Factitious Air, a term uſed by the Philoſophers of the laſt century inſtead of the preſent one, Fixed Air, which is almoſt as improper as a Solid Fluid. The different kinds of Factitious Air are explained in Somatiology, and are only conſidered in Pneumatics in ſo far as they relate to the deſtruction, or reſtoration of the vivifying quality in the atmoſphere.

Optics and Aſtronomy are the two laſt diviſions in this Syſtem. Light and Viſion are univerſally made the object of the firſt; and that of the ſecond is ſufficiently known by the Etymology of the word, and by what has been already ſaid under Gravitation and Mechanics.

Theſe obſervations are made for the ſake of ſuch as may happen to look into this volume without having ſeen the Experiments by which the Propoſitions are proved, or heard the Lectures by which the Outlines are explained. For the ſame reaſon it may be proper to add, that the Mathematical and Hiſtorical Parts of Natural Philoſophy are annually taught by the Author at a ſeparate Lecture; and ſo as to refer to the Experiments, which muſt ever be the only means of acquiring valuable knowledge in this branch of Philoſophy.

"Non fingendum, aut excogitandum, ſed inve-
"niendum, quid Natura faciat, aut ferat."

BACON, L. VER.

INTRODUCTION.

OF PHYSICS.

THE inducements to purſue this branch of Philoſophy;

From curioſity, from the love of beauty, truth, and grandeur;

From the advantages it brings to human life, by the improvement of arts, machines, and manufactures;

And from the manifold proofs it gives of wiſdom, power, and goodneſs in the creation.

Of the axioms and poſtulates in Phyſics.

Of the proper method of making experiments; and of the concluſions to be drawn from them, commonly called the rules of philoſophiſing.

Of the principal perſons who have improved this uſeful ſcience.

Of the parts into which it is divided; and an explanation of the following arrangement;

I.	SOMATIOLOGY.	
II.	MINERALOGY.	
III.	BOTANY.	
IV.	ZOOLOGY.	
V.	ELECTRICITY.	
VI.	MAGNETISM.	
VII.	GRAVITATION.	
VIII.	MECHANICS.	
IX.	HYDROSTATICS.	HYDROSTATICS. HYDRAULICS.
X.	PNEUMATICS.	
XI.	OPTICS.	CATOPTRICS. DIOPTRICS. CATADIOPTRICS.
XII.	ASTRONOMY.	

INSTITUTES

OF

PHYSICS.

PART I.

SOMATIOLOGY.

SECT. I.

OF SPACE AND TIME.

Space and Time are ſimple ideas. They are boundleſs, everlaſting, and capable of being divided by the mind without end. They are diſtinguiſhed into abſolute, and relative.

Though we know not enough of ſpace, and time, to gratify our curioſity; yet what we do know, is ſufficient for the happineſs of life.

SECT. II.

OF MATTER AND MOTION.

PROP. I.

Every piece of Matter is extended, moveable, inert; and no piece of Matter can, at the ſame time, be in the ſame part of Space, in which another piece of Matter is.

PROP. II.

Motion is a continued change of ſpace; Reſt is the contrary; and both are divided into abſolute and relative.

Of ſolid, fluid, hard, ſoft, elaſtic, and non-elaſtic Bodies, or Maſſes of Matter.

SECT. III.

OF SPACE VOID OF MATTER.

PROP. I.

There are bodies, of the ſame bulk or magnitude, and of unequal weights.

PROP. II.

The denſeſt bodies are full of pores; and they are moveable in the denſeſt fluids.

PROP. III.

If bodies, of the ſame bulk and unequal weights, are let fall in the air, the lighteſt will be ſenſibly retarded; but, in a place where there is no air, all bodies, however differing in weight, bulk, or ſhape, fall from the ſame heights with equal velocities.

Proofs from theſe facts, that all ſpace is not replete with matter.

Of other proofs of a vacuum.

SECT. IV.

OF THE IDEAL DIVISIBILITY OF MATTER.

PROP. I.

Every piece of matter, like every part of ſpace, may be divided by the mind, into a greater number of parts, than any that can be aſſigned.

PROP. II.

The difficulty, of conceiving the endleſs diviſibility of matter, is no juſt objection to its truth.

SECT. V.

OF THE ACTUAL DIVISIBILITY OF MATTER.

PROP. I.

One grain of gold may eaſily be divided into two millions of parts; and a cubic inch of gold, into nine billions, five hundred and twenty-three millions, eight hundred and nine thouſand, five hundred and twenty-three parts; each of which may be diſtinctly ſeen by the naked eye.

PROP. II.

A particle of ſand, ſo ſmall that a million of ſuch particles may be contained in a cubic inch, does contain two millions, one hundred and eleven thouſand, and four hundred ſuch parts as a ſingle grain of copper may be divided into; and yet be viſible without the help of a glaſs.

PROP. III.

The effluvia, of ſome odoriferous bodies, are leſs in bulk, than thirty-eight of the parts of an inch, though the inch were divided into a trillion of parts.

PROP. IV.

If the fluids in animalcules and men are in the ſame proportion to their reſpective bodies, a ſpace equal in bulk to the ſmalleſt grain of ſand that is viſible by the naked eye, would contain more of the globules of ſome of the fluids in animalcules, than a ſpace, equal in bulk to two hundred and ſixty-ſix of the higheſt mountains in the earth, would contain grains of ſand.

Of other proofs of the actual diviſibility of matter into parts ſo minute as to elude the conception of man.

SECT VI.

OF THE PRIMARY PARTICLES OF MATTER.

PROP. I.

All bodies, however different in qualities or forms, conſiſt of a few kinds of corpuſcles variouſly combined together; and the primary particles, principles, or elements of all bodies are commonly ſuppoſed to be Earth, Water, Air, Fire.

PROP. II.

The number of the primary particles is unknown. Perhaps there are but two kinds, from the various combinations of which, all the diverſity in bodies is produced.

PROP. III.

The uncertainty, concerning the number of the elements, ariſes from the imperfection of the human ſenſes, and from the Means by which the ſmall parts of matter are decompoſed.

SECT. VII.

OF THE SECONDARY PARTICLES OF MATTER.

PROP. I.

In all bodies there are minute particles of a ſecondary bulk, the properties of which can be aſcertained; and they may be reduced to ſeven claſſes, with their orders, diviſions, ſubdiviſions, and genera.

CLASS I.

EARTHS.

ORDER I.

SIMPLE EARTHS.

Genus.
1. Calcareous Earth.
2. Ponderoſa Earth.
3. Magneſia Earth.

Genus.
4. Argillaceous Earth.
5. Siliceous Earth.

ORDER II.

COMPOUND EARTHS.

DIVISION I.

CALCAREOUS BODIES.

	Genus.	
Ter. Cal.	1. Spathum.	*Acid. Mephit.*
Ter. Cal.	2. Gypſum.	*Acid. Vitriol.*
Ter. Cal.	3. Lap. Calcar.	*Meph. Ar. Fer.*

	Genus.	
Ter. Cal.	4. Tungſten.	*Acid. Spathi.*
Ter. Cal.	5. Fluor.	*Acid. Tungsten,*
Ter. Cal.	6. Creutzen.	*Ter. Magnesia.*
Ter. Cal.	7. Travertino.	*Ter. Argillacea,*
Ter. Cal.	8. Marga.	*Ter. Barytica,*
Ter. Cal.	9. Gritcalcar.	*Ter. Silicea,*
Ter. Cal.	10. Lapis Suillus.	*Ol. Foſſile.*
Ter. Cal.	11. Pyritcalcar.	*Pyrites.*
Ter. Cal.	12. Fercalcar.	*Ferrum.*
Ter. Cal.	13. Calponderos.	*Ter. Pond.*
Ter. Cal.	14. Calmuriat.	*Ter. Mur.*
Ter. Cal.	15. Calargil.	*Ter. Argil.*
Ter. Cal.	16. Calsilex.	*Ter. Sil.*
Ter. Cal.	17. Calporphyrit.	*Ter. Porph.*
Ter. Cal.	18. Teſtacea.	*Alk. Meph. Sil,*
Ter. Cal.	19. Ciner. Veget.	*Alk. Corp. Veg.*
Ter. Cal.	20. Ciner. Anim.	*Ac. Phos. Var.*

DIVISION II.

PONDEROSA BODIES.

	Genus.	
Ter. Baryt.	1. Baroselenites.	*Acid. Mephit.*
Ter. Baryt.	2. Lap. Bononiens.	*Acid. Vitriolic.*
Ter. Baryt.	3. Ponacidspat.	*Acid. Spathi.*
Ter. Baryt.	4. Pontungspat.	*Acid. Tungsten.*
Ter. Baryt.	5. Ponsilfer.	*Ter. Sil. Fer.*
Ter. Baryt.	6. Lap. Hepaticus.	*Ter. Sil. Ol. Fos.*

DIVISION III.

MAGNESIA BODIES.

	Genus.	
Ter. Mag.	1. Keffekill.	*Sil. Mephit.*
Ter. Mag.	2. Steatites.	*Ter. Sil. Argil.*
Ter. Mag.	3. Aſbeſtos.	*Sil. Argil. Fer.*
Ter. Mag.	4. Amianthus.	*Baryt. Arg. Fer.*
Ter. Mag.	5. Serpentinus.	*Sil. Arg. Aqua.*
Ter. Mag.	6. Talcum.	*Sil. Argil.*
Ter. Mag.	7. Magacidspat.	*Acid. Spathi.*
Ter. Mag.	8. Magacidtung.	*Ac. Tungsten.*
Ter. Mag.	9. Magmixtae.	*Mixtae.*
Ter. Mag.	10. Magcalcar.	*Ter. Cal.*
Ter. Mag.	11. Magponderos.	*Ter. Pond.*
Ter. Mag.	12. Magargil.	*Ter. Argil.*
Ter. Mag.	13. Magsilex.	*Ter. Sil.*

DIVISION IV.

ARGILLACEOUS BODIES.

	Genus.	
Ter. Arg.	1. Agaric. Miner.	*Acid. Mephit.*
Ter. Arg.	2. Argilla.	*Sil. Aqua. Fer.*
Ter. Arg.	3. Embryal.	*Acid. Vitriolic.*
Ter. Arg.	4. Embmaral.	*Acid. Marin.*
Ter. Arg.	5. Mica.	*Sil. Mag. Fer.*
Ter. Arg.	6. Shiſt. Tegul.	*Fer. Ol. Foſ.*
Ter. Arg.	7. Shiſt. Pyrit.	*Pyrit. Mag.*
Ter. Arg.	8. Shiſt. Bitum.	*Pyrit. Ol. Foſ.*
Ter. Arg.	9. Gritargil.	*Ter. Sil. Fer.*

	Genus.	
Ter. Arg.	10. Hornſten.	*Sil. Mag. Fer.*
Ter. Arg.	11. Lap. Bufonis.	*Sil. Cal. Fer.*
Ter. Arg.	12. Zeolites.	*Ter. Cal. Aqua.*
Ter. Arg.	13. Creta Rubra.	*Ar. Fer. Steat.*
Ter. Arg.	14. Argilmixtae.	*Mixtae.*
Ter. Arg.	15. Argilcalcar.	*Ter. Cal.*
Ter. Arg.	16. Argilponderos.	*Ter. Pond.*
Ter. Arg.	17. Argilmuriat.	*Ter. Mag.*
Ter. Arg.	18. Argilsilex.	*Ter. Sil.*
Ter. Arg.	19. Argilmica.	*Ter. Micacea.*

DIVISION V.

SILICEOUS BODIES.

	Genus.	
Ter. Sil.	1. Quart. Cryſt.	*Ter. Cal. Argil.*
Ter. Sil.	2. Silex.	*Cal. Arg. Var.*
Ter. Sil.	3. Petrosilex.	*Arg. Cal. Var.*
Ter. Sil.	4. Jaſper.	*Arg. Cal. Fer.*
Ter. Sil.	5. Agates.	*Ter. Var. Fer.*
Ter. Sil.	6. Gemmae.	*Arg. Cal. Fer.*
Ter. Sil.	7. Chryſopras.	*Cal. Mag. Cupr.*
Ter. Sil.	8. Lap. Lazuli.	*Mar. Fluor Gyp.*
Ter. Sil.	9. Lap. Amazon.	*Mag. Fer.*
Ter. Sil.	10. Petunſe.	*Ar. Baryt. Mag.*
Ter. Sil.	11. Petrogarnet.	*Ar. Cal. Fer.*
Ter. Sil.	12. Shoerl.	*Ar. Fer. Mag.*
Ter. Sil.	13. Barshoerl.	*Ar. Mag. Aqua.*
Ter. Sil.	14. Tourmalin.	*Ar. Cal. Fer.*
Ter. Sil.	15. Basaltes.	*Ar. Mag. Fer.*

	Genus.	
Ter. Sil.	16. Silarfer.	*Argil. Fer.*
Ter. Sil.	17. Lap. Monnet.	*Spt. Mur. Fer.*
Ter. Sil.	18. Cos Turcica.	*Ter. Cal.*
Ter. Sil.	19. Cos Granosa.	*Ter. Cal. Fer.*
Ter. Sil.	20. Gritsilex.	*Quart. Ar. Fer.*
Ter. Sil.	21. Silmixtae.	*Corp. Silicea.*
Ter. Sil.	22. Silcalcar.	*Ter. Calcarea.*
Ter. Sil.	23. Silponderos.	*Ter. Ponder.*
Ter. Sil.	24. Silmuriat.	*Ter. Mag.*
Ter. Sil.	25. Silargil.	*Ter. Argil.*
Ter. Sil.	26. Silmandel.	*Mandelsten.*

ORDER III.

EARTHY LAVAS.

Genus.
1. Lava Cellularia.
2. Lava Compacta.

Genus.
3. Lava Vitrea.
4. Semilava.

ORDER IV.

EARTHY PETREFACTIONS.

Genus.
1. Calcarea Petrefact.
2. Argillacea Petrefact.

Genus.
3. Silicea Petrefact.
4. Lithomorphi.

ORDER V.

MOULDS.

Genus.
1. Humus Vegetabilis.

Genus.
2. Humus Animalis.

CLASS II.

SALTS.

ORDER I.

SIMPLE SALTS.

DIVISION I.

ACIDS.

SUBDIVISION I.

MINERAL ACIDS.

Genus.
1. Acid. Mephiticum.
2. Acid. Vitrioli.
3. Acid. Nitri.
4. Acid. Marinum.
5. Acid. Spathi.
6. Acid. Tungsteni.

Genus.
7. Acid. Arſeneci.
8. Acid. Molybden.
9. Acid. Boracis.
10. Acid. Succini.
11. Acid. Phoſphori.*

SUBDIVISION 2.

VEGETABLE ACIDS.

Genus.
1. Acid. Aceti.
2. Acid. Tartari.

Genus.
3. Acid. Eſſ. Vegetab.
4. Acid. Muſti.

SUBDIVISION 3.

ANIMAL ACIDS.

Genus.
1. Acid. Phoſphor.
2. Acid. Inſector.

Genus.
3. Acid. Stomachi.
Alia Acid. Anim.

DIVISION II.

ALKALIS.

SUBDIVISION 1.

FIXED ALKALIS.

Genus.
1. Vegetable Fix. Alkali.

Genus.
2. Foſſil Fix. Alkali.

SUBDIVISION 2.

VOLATILE ALKALI.

Genus.
1. Alkali Volatile.

ORDER II.

COMPOUND SALTS.

DIVISION I.

NEUTRAL SALTS.

	Genus.	
Vit. Acid.	1. Tartar. Vitrioli.	*Veg. Alk.*
Vit. Acid.	2. Sal Glauberi.	*Fos. Alk*
Vit. Acid.	3. Am. Vitriolat.	*Vol. Alk*

	Genus.	
Nit. Acid.	4. Nitrum Com.	*Veg. Alk.*
Nit. Acid.	5. Nitrum Cub.	*Fos. Alk.*
Nit. Acid.	6. Nitrum. Am.	*Vol. Alk.*
Mur. Acid.	7. Sal Digeſt. Silvii.	*Veg. Alk.*
Mur. Acid.	8. Sal Commune.	*Fos. Alk.*
Mur. Acid.	9. Sal Amm. Com.	*Vol. Alk.*
Veg. Acid.	10. Tartar. Regenerat.	*Veg. Alk.*
Veg. Acid.	11. Polychreſt. Rochel.	*Fos. Alk.*
Veg. Acid.	12. Spiritus Mindereri.	*Vol. Alk.*
Mur. Acid.	13. Sal Sedativum.	*Phlog.* (*incert.*)
Sal Sedat.	14. Borax.	*Alk.* (*incert.*)

DIVISION II.

EARTHY SALTS.

	Genus.	
Vit. Acid.	1. Gypſa.*	*Ter. Cal.*
Vit. Acid.	2. Sal Cathar. Amar.	*Magnesia.*
Vit. Acid.	3. Alumen.	*Argilla.*
Vit. Acid.	4. Minera Aluminis.	*Arg. Var.*
Mur. Acid.	5. Sal. Am. Fixum.	*Ter. Cal.*

DIVISION III.

METALLIC SALTS.

	Genus.	
Vit. Acid.	1. Turpeth. Mineral.	*Hydrarg.*
Vit. Acid.	2. Vitriolum Coerul.	*Cuprum.*
Vit. Acid.	3. Vitriol. Viride.	*Ferrum.*

	Genus.	
Vit. Acid.	4. Vitriol. Album.	*Zincum.*
Vit. Acid.	5. Vitr. Manganesi.	*Manganes.*
Nit. Acid.	6. Cauſticum Lunare.	*Argentum.*
Nit. Acid.	7. Mercurii Solutio.	*Hydrarg.*
Nit. Acid.	8. Veneris Solutio.	*Cuprum.*
Nit. Acid.	9. Saturni Solutio.	*Plumbum.*
Nit. Acid.	10. Martis Solutio.	*Ferrum.*
Nit. Acid.	11. Cobalti Solutio.	*Cobaltum.*
Nit. Acid.	12. Zinci Solutio.	*Zincum.*
Nit. Acid.	13. Nickeli Solutio.	*Nickelum.*
Mur. Acid.	14. Luna Cornea.	*Argentum.*
Mur. Acid.	15. Mer. Corrosiv.	*Hydrarg.*
Mur. Acid.	16. Saturnus Corneus.	*Plumbum.*
Mur. Acid.	17. Atram. Sympath.	*Cobaltum.*
Mur. Acid.	18. Baroſelenites*.	*Ter. Baryt.*
Veg. Acid.	19. Aerugo.	*Cuprum.*
Veg. Acid.	20. Sacchar. Saturni.	*Plumbum.*

ORDER III.

SALINE LAVAS.

Genus.
1. Lava Cellularia.
2. Lava Compacta.

Genus.
3. Lava Vitrea
4. Semilava.

ORDER IV.

SALINE PETREFACTIONS.

Genus.
1. Petrefacta Veg. Sal.

Genus.
2. Petrefacta Anim. Sal.

CLASS III.

AIR.

ORDER I.

SIMPLE AIR.

Genus.

1. Aer Purus.

ORDER II.

COMPOUND AIR.

DIVISION I.

ATMOSPHERIC AIR.

Genus.

Aer Purus.	1. Aer Communis.	*Aer Mephit.*
Aer Com.	2. Aer Aqueus.	*Aqua.*
Aer Com.	3. Aer Effluvioſus.	*Effluviæ.*

DIVISION II.

FACTITIOUS AIR.

SUBDIVISION I.

SALUTARY FAC. AIR.

Genus.

Acid. Nit.	1. Aer Nitrigneus.	*Ig. Zinc. Var.*
Acid. Vit.	2. Aer Vitminius.	*Min. Ig.*
Ignis Purus.	3. Aer Solminius.	*Minium.*
Salpetrum.	4. Aer Salpetrus.	*Ig. Com.*

	Genus.	
Ac. Vitr.	5. Aer Vitcuprius.	*Cup. Ig.*
Mercur.	6. Aer Mernitrus.	*Acid. Nit.*

SUBDIVISION 2.

NOXIOUS FAC. AIR.

	Genus.	
Phlogiſton.	1. Aer Mephit. *	*Aer Pur. Ig.*
Ig. Quieſc.	2. Aer Inflammab.*	*Aq. Fer. Vit. Ac.*
Corp. Var.	3. Aer Fermenti.	*Aer Mephit.*
Aer Com.	4. Aer Pulmonicus.	*Aer Mephit.*
Aer Com.	5. Aer Aduſtus.	*Ig. Aer Meph.*
Phlogiſton.	6. Aer Vitracidus.	*Acid. Vitriol.*
Vap. Nitri.	7. Aer Nitroſus.	*Phlog. Aqua.*
Vap. Ac. Mur.	8. Aer Muracidus.	*Phlogiſton.*
Aer Inflam.	9. Aer Alkalinus.	*Aer Mephit.*
Ac. Spat.	10. Aer Spathoſus.	*Ter. Spathi.*
Sulph.	11. Aer Hepaticus.	*Ter. Alk.*

CLASS IV.

INFLAMMABLES.

ORDER I.

PHLOGISTON.

	Genus.	
Ig. Quieſc.	1. Phlogiſton.	Incertum.

ORDER II.

CAMINAIA.

	Genus.	
Phlogiſton.	1. Adamas.	Incertum.
Phlogiſton.	2. Plumbago.	*Ter. Sil. Fer.*

ORDER III.

PHLOGINA.

DIVISION I.

INFLAMMABLE AIR.

SUBDIVISION 1.

MINERAL INFLAMMABLE AIR.

	Genus.	
Vit. Acid.	1. Aer Fodin. Ig. *	*Fer. Aqua.*
Mur. Acid.	2. Aer Antimonii.	*Reg. Antim.*
Mur. Acid.	3. Aer Cupreus.	*Cuprum.*
Sulphur.	4. Aer Sulferreus.	*Ferrum.*

SUBDIVISION 2.

VEGETABLE INFLAMMABLE AIR.

	Genus.	
Veg. Partes.	1. Aer Planputridus.	*Putrescen.*
Vapor.	2. Aer Fraxinellus.	*Fraxinella.*
Vap. Camph.	3. Aer Camphorat.	*Alcohol.*
Vapor.	4. Aer Etherius.	*Alc. Ether.*

SUBDIVISION 3.

ANIMAL INFLAMMABLE AIR.

	Genus.	
Corp. Anim.	1. Aer Putranimalis.	*Putrescen.*
Corp. Alim.	2. Aer Alimentarius.	*Putrescen.*

DIVISION II.

ALCOHOL.

	Genus.	
Phlogiston.	1. Spiritus Ardens.	*Aqua Pura.*
Vitr. Ac.	2. Ether Vitriol.	*Phlog. Aqua.*
Mur. Ac.	3. Ether Muriat.	*Phlog. Aqua.*
Nit. Ac.	4. Ether Nitros.	*Phlog. Aqua.*
Acet. Ac.	5. Ether Acetos.	*Phlog. Aqua.*

DIVISION III.

SULPHUR.

	Genus.	
Vit. Acid.	1. Sulphur Purum.	*Phlogiston.*
Sulphur.	2. Sulphuris Miner.	*Corp. Fos.*

DIVISION IV.

CHARCOAL.

	Genus.	
Phlog. Sal.	1. Carbo Lignar.	*Ter. Alk.*
Phlogist.	2. Carbo Animal.	*Ter. Alk.*

DIVISION V.

OIL.

SUBDIVISION I.

FOSSIL OIL.

	Genus.	
Ol. Fos.	1. Naphta.	*(Incert.)*

	Genus.	
Ol. Fos.	2. Petroleum.	*Phl. Aer Com.*
Ol. Fos.	3. Maltha.	*Ac. Succi.*
Ol. Fos.	4. Aſphaltum.	*Sulphur.*
Ol. Fos.	5. Gagates.	*(Incert.)*
Ol. Fos.	6. Lithanthrax.	*Argil. Var.*
Ol. Fos.	7. Geanthrax.	*Vegetab.*
Ol. Fos.	8. Succinum.	*Aqua.*
Ol. Fos.	9. Ambergriseum.	*Ol. Anim.*

SUBDIVISION 2.

VEGETABLE OIL.

	Genus.	
Ol. Veg.	1. Ol. Veg. Expreſs.	*Phlogiſt.*
Ol. Veg.	2. Ol. Veg. Eſſent.	*Effluv. Veg.*

Of Gums, Resins, Sugar, Camphor, Wood.

SUBDIVISION 3.

ANIMAL OIL.

	Genus.	
Ol. Anim.	1. Ol. Anim. Expr.	*Ac. Anim.*
Ol. Anim.	2. Ol. Anim. Eſſ.	*Alk. Volat.*

Of Milk, Gall, and various Animal Substances.

ORDER IV.

FULMINATING POWDERS.

	Genus.	
Nitrum.	1. Pulvis Tormenti.	*Car. Sulph.*
Nitrum.	2. Pul. Fulminans.	*Alk. Tar. Sul.*
Aq. Reg.	3. Aurum Fulmin.	*Aur. Alk.*

ORDER V.

PHOSPHORI.

	Genus.	
Ac. Phos.	1. Phos. Brandti.	*Ph. An. Corp.*
Ac. Phos.	2. Ph. Margraafii.	*Veg. Corp.*

Of Noctilucae.

CLASS V.

METALLICS.

DIVISION I.

METALS.

Perfect.	Imperfect.
Genus.	Genus.
1. Aurum.	5. Cuprum.
2. Platina.	6. Ferrum.
3. Argent. Vivum.	7. Stannum.
4. Argentum.	8. Plumbum.

DIVISION II.

SEMI-METALS.

Genus.
1. Bismuthum.
2. Nickelum.
3. Zincum.
4. Reg. Antimonii.
5. Reg. Arsenici.

Genus.
6. Reg. Cobalti.
7. Reg. Syderitis.
8. Reg. Manganesi.
9. Reg. Molybdenae.

DIVISION III.

ORES.

SUBDIVISION 1.

ORES OF METALS.

Genus.
1. Minera Auri.
2. Min. Platinae.
3. Min. Mercurii.
4. Min. Argenti.

Genus.
5. Min. Cupri.
6. Min. Ferri.
7. Min. Stanni.
8. Min. Plumbi.

SUBDIVISION 2.

ORES OF SEMI-METALS.

Genus.
1. Min. Biſmuthi.
2. Min. Nickeli.
3. Min. Zinci.
4. Min. Antimonii.
5. Min. Arsenici.

Genus.
6. Min. Cobalti.
7. Min. Syderitis.
8. Min. Manganesi.
9. Min. Molybdenae.

CLASS VI.

WATER.

ORDER I.

SIMPLE WATER.

Genus.
1. Aqua Pura.

ORDER II.

COMPOUND WATER.

DIVISION I.

EARTHY WATER.

Genus.
1. Aqua Calcarea.
2. Aqua Ponderosa.
3. Aqua Magnesia.

Genus.
4. Aqua Argillacea.
5. Aqua Silicea.

DIVISION II.

SALINE WATER.

Genus.
1. Aq. Acida.

Genus.
2. Aq. Alkalina.

DIVISION III.

AERATED WATER.

Genus.
1. Aerpura Aqua.

Genus.
2. Aercomposit. Aqua.

DIVISION IV.

PHLOGISTIC WATER.

Genus.
1. Aqua Oleoſa.
2. Aqua Putrefacta.

Genus.
3. Aqua Sulphurea.

DIVISION V.

METALLIC WATER.

Genus.
1. Aqua Cuprea.

Genus.
2. Aqua Ferrea.

CLASS VII.

FIRE.

Genus.
1. Ignis Quieſcens.
2. Ignis Calfaciens.

Genus.
3. Ignis Lucens.
4. Ignis Callucens.

CHARACTERS

Of the above Claſſes, Orders, Diviſions, and Subdiviſions; and of ſome of the Genera.

CLASS I.

Solid bodies, commonly called Earths and Stones, which are not ſaltiſh to the taſte; which will not burn like the three laſt orders of Inflammables; and which are not malleable.

ORDER I.

Such as cannot be decompoſed by any of the operations of art, that are yet known.

GENUS I.

When perfectly ſimple, requires 680 times its weight of water, at 60° of heat, to diſſolve it; is ſoluble in all the Acids; and in the Nitrous, or Marine, forms deliqueſcent ſalts; corrodes Animal Bodies; is not fuſible in a furnace heat, when unmixed; but is eaſily fuſed when mixed with other bodies; its Specific Gravity, or weight, compared to an equal bulk of rain water, is as 2,300 to 1,000.

GENUS II.

Called likewiſe Barytes, requires 900 times its weight of water to diſſolve it; is ſoluble in all the Acids; with the Nitrous, or Marine, forms Non-deliqueſcent Salts; and with the Vitriolic, a ſalt of more difficult ſolution than Gypſum. It decompoſes vitriolated tartar; is precipitated in the nitrous and marine acids by Pruſſian Alkali; its fuſibility with other bodies is nearly as that of the laſt Genus; and its Specific Gravity about 4,000.

GENUS III.

Is alſo called Muriatic, requires about 7,690 times its weight of water to diſſolve it. With the Vitriolic Acid it forms Epſom Salt. It is not fuſible when unmixed; but is eaſily fuſed with calcareous, argillaceous, and ſiliceous Earths altogether. Its Specific Gravity is about 2,33.

GENUS IV.

Or, Earth of Alum, requires about 7,700 times its weight of water to diſſolve it. With the Vitriolic Acid, it forms Alum. It is precipitated by the Acid of Sugar. Is not fuſible when unmixed; but readily with Calcareous Earth, with Borax, or Microcoſmic Salt. Its Specific Gravity is about 2,000.

GENUS V.

Called alſo the Quartz Earth, Chryſtaline, or Vitrifiable, requires about 10,000 times its weight of water to diſſolve it; is ſoluble in no Acid but the Fluor; is ſharp to the touch; is not fuſible when unmixed; but eaſily, when mixed with half its weight of fixed Alkali, or with Calcareous and Argillaceous Earths together. Its Specific Gravity is about 2,65.

ORDER II.

Such as can be decompoſed; and the conſtituent parts of which are, as in the following Diviſions.

DIVIS. I

Calcareous earth intimately compounded with other bodies; as marked at the ſides of the Genera, and in Mineralogy.

DIVIS. II.

Ponderoſa earth intimately compounded with other bodies; according to their Genera.

Divis. III. Magneſia Bodies; Divis. IV. Argillaceous Bodies; and Divis. V. Siliceous Bodies, are compounded in a ſimilar manner.

ORDER III.

Called alſo Scoriae; are Earthy Bodies which have been changed by volcanic fires, they having the ſame properties with certain Earthy Bodies, that have undergone artificial furnace heats.

The appearances, and properties of Lavas, are greatly diverſified; according to the nature of the bodies which are melted in the bowels, and on the ſurface of the earth; and according to the degrees of heat.

ORDER IV.

Animal and vegetable bodies found in the earth in a ſolid ſtate; and the properties of which have been changed by earthy bodies.

ORDER V.

Rotten vegetable and animal bodies, upon, or near the ſurface of the earth; and which are not in homogeneous maſſes.

CLASS II.

Bodies which are ſaltiſh to the taſte; and which may be diſſolved in leſs than 200 times their weight of boiling water.

ORDER I.

Saline bodies which are not decompoſed by the common operations of art; many of them being only ſimple, in oppoſition to the next Order.

DIVISION I.

Are never almoſt found uncombined; they have a ſour taſte; give a red tinge to moſt of the blue juices of Vegetables; unite eaſily with Alkalies; and diſſolve the ſolid, but coagulate the fluid, parts of Animals.

SUBDIVIS. I.

Such as are commonly got in the mineral kingdom.

GENUS I.

Or, Choke Damp, Gas Sylveſtre, Fixed Air, Calcareous Air, Phlogiſticated Air, Aerial Acid; is produced from calcareous Bodies; from fixed, and volatile Alkalies; from Magneſia; and from many other bodies. Beſides the general properties of an Acid, it extinguiſhes flame and animal life; reſiſts putrefaction; diſſolves calcareous Earth, Magneſia, and Iron in Water; and ſerves to unite the particles of many Bodies. Its Specific Gravity is 0,511; and, if compared to Common Air, it is as 157 to 100, when the Common Air is 800 times lighter than Water.

GENUS II.

Called alſo the univerſal, and wandering Acid; when pure, is without ſmell and colour; and its Specific Gravity is 18,775. It effervеſces when it unites with water; and has different names and appearances, according to its purity.

GENUS III.

Nitrous Acid is produced by joining Earth, and Air to the putrid juices of animal and vegetable bodies; it exhales in yellow vapours; has a peculiar ſmell, and is corroſive. When mixed with water is Aqua Fortis; and with the marine Acid, or Sal Ammoniac, Aqua Regia.

GENUS IV.

Or, Muriatic, has a ſmell like Saffron, is of a whitiſh colour; forms common Salt with the Foſſil Alkali; and its Specific Gravity is 13.

GENUS V.

Called likewiſe the Spat, or Fluor Acid; by contact with water depoſites a Siliceous Earth; and its vapour, when hot, corrodes Glaſs.

GENUS VI.

Tungſten Acid, with lime water, produces the body called Tungſten, or Lapis Ponderoſus.

GENUS VII.

Arſenical Acid, when heated in contact with bodies that give Phlogiſton, generates Arſenic.

GENUS VIII.

Produced from Molybdena; tinges Borax, and Microcoſmic Salt, when heated with them.

GENUS IX.

Or, Acid of ſedative Salt, is fuſible; is volatile with water; and its Specific Gravity is 1,48.

GENUS X.

Is got from Amber; and the Neutral Salts formed with it do not make any precipitation in the nitrous ſolution of Silver.

GENUS XI.

Phoſphorine Acid is dried and vitrified, but not made volatile by heat. It diſſolves white Arſenic and Zinc; and has a peculiar ſmell.

There are other bodies which may be placed either here, or in the Diviſion of Factitious Air, according as their acid or aerial qualities are conſidered.

SUBDIVIS. 2.

Comprehends Acids got from vegetable Bodies.

GENUS I.

The Acetous Acid has a well-known colour, taſte, and ſmell, its Specific Gravity is 1,011; it acts not upon Gold, Platina, Mercury, or Silver; but upon Copper, Zinc, and Lead.

The ſecond Genus is got from the tartar of Vegetables; the third, from Vegetable Eſſential Oils; and, the fourth, from unfermented Acid Fruits. Their Characters are not fully known.

SUBDIVIS. 3.

So called, becauſe moſt commonly got in the animal kingdom.

The Character of the firſt Genus is given under the mineral Acids. It is, however, ſeldom found among Foſſils; being commonly the product of vegetable and animal Bodies, and of Art. The ſecond Genus reſembles the Acetous Acid, but has diſtinguiſhing properties. Other acids have been got from animal Bodies; and they ſeem to have peculiar characters, which are not fully aſcertained.

DIVISION II.

Alkalies have a pungent acrid taſte; make the blue juice of vegetables green; unite eaſily with Acids and Water; and promote the fuſion and vitrification of Earths.

SUBDIVIS. I.

Such as are not diſſipated by the heat of boiling Water.

GENUS I.

The Vegetable Fixed Alkali forms a deliqueſcent Salt with the Acetous Acid; imbibes moiſture from the the Air, becoming fluid, and cauſtic; is mild in a cryſtalized ſtate; and effervеſces with Acids; unites with Oils, and makes them unite with Water; and forms glaſs when fuſed with earths.

GENUS II.

Called anciently Nitrum, and Natrum, forms a foliated Salt, which cryſtalizes with the Acetous Acid; and has moſt of the properties of the laſt Genus.

SUBDIVIS. 2.

Is diſſipated by a heat leſs than that of boiling Water.

GENUS I.

Volatile Alkali has a peculiar taſte, and pungent ſmell; forms cryſtals when it concretes; and gives a blue colour to the ſolutions of Copper, in Mineral Acids.

ORDER II.

Comprehends bodies compoſed of Acids, joined to Alkalies, to Earths, or to Metallic Bodies.

DIVISION I.

Neutral Salts are compoſed of Acids, joined to Alkalies, and which have properties different from both.

DIVISION II.

Earthy Salts are compoſed of acids joined to earths,

DIVISION III.

Metallic Salts are acids joined to metallic Bodies.

ORDER III.

Lavas are Saline Bodies, which have been changed by volcanic fires; they having the ſame properties with certain Saline Bodies, that have been in artificial Furnaces.

ORDER IV.

Saline Petrefactions are vegetable and animal Bodies, found in the earth in a ſolid ſtate; and the properties of which have been changed by Saline Bodies.

CLASS III.

An elaſtic fluid, not deſtroyed, nor rendered ſolid by cold.

ORDER I.

Called likewiſe dephlogiſticated, and Empyreal Air; is only ſimple, when compared to the next Order, for it ſeems to be water deprived of Phlogiſton, and united with fire in a quieſcent ſtate. Its Specific Gravity is a little greater than that of Common Air; and it ſupports animal Life, and Flame about ten times longer. It is produced by various degrees of Heat, and with different degrees of Purity, from metallic, and calcareous Earths, from Mercury diſſolved in the Spirit of Nitre; from the other metals diſſolved in the vitriolic Acid; from earthy Bodies united with that Acid; and from Alum, Quick Lime, and Vitriol. It is produced likewiſe from Common Water and Sea Water, from ſeveral Vegetables; and from ſome of them not without expoſure to light.

ORDER II.

Is compounded of Pure Air, and of one or more of the other Genera of Air.

DIVISION I.

That Air which is the ſubject of Pneumatics; which reaches to the loweſt parts in the Earth; and to at leaſt between forty and fifty miles above it.

GENUS I.

Atmoſpheric Air near the Level of the Sea; its Specific Gravity is 914, when the Barometer is about 30 inches high. An Engliſh Gallon of it will maintain the life of a man, about a minute; and the flame of a tallow candle, of four to the pound, about the ſame time. If a maſs of this Air is divided into four parts, one of them is Pure Air, and the remainder is Mephitic; but there are local and temporary variations from this proportion.

GENUS II.

Common Air, in which Water is diſſolved, and of which it will ſuſtain different quantities, according to its temperature.

GENUS. III.

Is Common Air, in which the ſmall particles of Bodies, ſpecifically lighter than Common Air, are ſuſpended; and which render it more or leſs ſalutary, according to the Nature of theſe Particles.

DIVISION II.

Bodies, which though they have the Character of this Claſs as above given, were not called Air till of late; but were conſidered as vapours, or ſome-thing different from Air, that caſually aroſe in Caverns; or that was the unintereſting Product of Art.

SUBDIVIS. I.

Factitious Air, which will preſerve animal Life and Flame; and the time during which it will preſerve them, compared to Pure Air, varies according to their kinds, and the Periods in the Proceſs by which they are generated.

GENUS I. II. III. IV. V. VI.

The firſt is produced by the application of Fire to Nitre, and various bodies. The ſecond, by the application of Fire to Minium, and the Vitriolic Acid. The third, by throwing the Sun's Rays with a burning Glaſs upon Minium. The fourth, by the application of common Fire to Nitre. The fifth, by the application of common Fire to the Vitriolic Acid and Copper. And the ſixth by joining Mercury, and the Nitrous Acid together.

SUBDIVIS. 2.

Air which deſtroys Animal Life, and Flame; and with various degrees of celerity, according to the bodies from which it is produced, and the nature of the animals which breathe it. Habit too makes another variation; there being an Accommodating-Power in the bodies, as well as in the minds of Men.

GENUS I.

This Air is generated by the application of Fire, or of Acids, to calcareous Bodies: other particulars relating to it being given above, under the Mineral Acids.

GENUS II.

Or, the Fire Damp of Miners; it is produced from a mixture of the vitriolic Acid, with Water and Iron; from Zinc, Pitch, Amber, Shells, and Coals; and from putrefying animal or vegetable Bodies; which form various Species of it with properties that are not fully known; in Specific Gravity, it is from four to ten times lighter than Common Air, according to the bodies from which it is got, and the time in which it is generated.

GENUS III.

Is of two kinds; being got from vegetable Subſtances, while they undergo the vinous fermentation; or, from animal, and vegetable Subſtances, when undergoing the putrefactive Fermentation. The firſt is Mephitic Air; and the ſecond conſiſts of the Mephitic, and the Inflammable mixed together.

GENUS IV.

Common Air is converted into this Air, by merely paſſing through the lungs of Animals when they breathe. It has the Properties of Mephitic Air with ſmall variations.

GENUS V.

When Common Air paſſes through Fire made of common Fuel, and burning in the uſual way, it is converted into this Air, which is Mephitic, with variations according to the Time, and Nature of the Fire.

GENUS VI.

By mixing the Vitriolic Acid with Oils, Charcoal, or other Inflammable Bodies, this Genus is produced; it is a little heavier than Common Air; is abſorbed by Charcoal; diſſolved by Camphor; and does not act upon Iron, Nitre or common Salt.

GENUS VII.

This Air is generated by diſſolving Iron, Copper, Mercury, Silver, Biſmuth, or Nickel, in the Nitrous Acid; and by diſſolving Gold, or Reg. of Antimony in Aqua Regia. When joined to Common Air, it produces heat; the mixture becomes red; and leſs in bulk than the two fluids which compoſe it; but, when ſaturated with Common Air, any farther addition produces neither heat nor redneſs, and makes an equal addition to the bulk of the mixture. When it is mixed with Mephitic Air, there is no diminution of its bulk; and, when with Common Air, the diminution is in proportion to the ſalutary quality which that Air poſſeſſed; its Specific Gravity to Common Air is as 157 to 152.

GENUS VIII.

During the diſtillation of Spirit of Salt by the Oil of Vitriol, this Air is produced, which melts Ice as quickly as a hot fire; and acts upon many Inflammable, and Metallic Bodies; its Specific Gravity to Common Air is as 243 to 152.

GENUS IX.

Is made by the application of Fire to Volatile Alkali; is in Specific Gravity to Common Air as 70 to 152; it unites with moſt of the other Genera; and, when water is ſaturated with it, the remainder becomes Inflammable.

GENUS X.

Called Fluor, or Spar Acid Air, is generated by diſtilling the Spars called Fluors, with the Vitriolic Acid: When it comes in contact with water, part of it is abſorbed, and the ſurface of the water is covered with a Film, which ſeems to be a Quartz; it corrodes Glaſs when hot; it is abſorbed by Charcoal, Ruſt of Iron, and Alum; its Specific Gravity to Common Air is as 450 to 152.

GENUS XI.

This Genus is procured from the Liver of Sulphur, and from ſeveral other bodies; it is not decompoſed by all the ſame bodies which decompoſe Sulphur; after it has been united with water for ſome days, it will ſeparate of itſelf, and fall to the bottom; it ſupports flame in certain circumſtances; and is inflammable.

Eudiometers of different kinds explained, with their advantages, and diſadvantages.

CLASS IV.

Bodies which will take fire and burn; and which have not the Characters of the Metallic Claſs.

ORDER I.

Phlogiſton is the Principle of Inflammability; which cannot be got ſimple and decompoſed; but which is eaſily conveyed from one Body to another. Its nature is not fully underſtood; perhaps it is Fire in a quieſcent State, and modified in a manner that is unknown.

ORDER II.

The Bodies of this Claſs, which will only take fire and burn, when a furnace-heat is applied, belong to this order.

GENUS I

Diamonds, in a heat a little greater than that which melts Silver, burn with a ſmall flame; and are entirely conſumed; diminiſhing Common Air, and yielding Soot.

GENUS II.

Commonly called Black Lead, is entirely conſumed in a great furnace-heat, and open fire; excepting a little Iron, and Cryſtalline Earth, that remains.

ORDER III.

Comprehends the Bodies of this Claſs which will take fire and burn, by the application of a weak flame, ſuch as that of a Candle.

DIVISION I.

Is Air that will take fire and burn. The Genera of it are comprehended under the Noxious Airs, above deſcribed; excepting, the ſecond and third of the ſecond Subdiviſion; the firſt of which is the natural Effluvia of a Plant, and the ſecond is the artificial Vapour ariſing from Alcohol, and Camphor.

DIVISION II.

Ardent Spirits, or Spirits of Wine, unites fully with Water; diſſolves Eſſential Oils; and, when pure, burns without Smoke, or Soot. The Ethers will evaporate with a heat leſs than that of the human Body; and ſome of them will diſſolve Gums, upon which the beſt Spirit of Wine will not act.

DIVISION III.

This is a Compound of Water and Phlogiſton; is not ſoluble in Water, in Ardent Spirits, or in Acids; but is ſoluble in Oils.

DIVISION IV.

Charcoal is made by burning Wood, without allowing it to flame; it is not acted upon by Water, by Acids, or by any Body, excepting Fire; but, when on Fire, the mineral Acids act upon it, if they are combined with other Bodies.

DIVISION V.

Oil burns, and is conſumed with Flame, and Smoke; it is compoſed of Phlogiſton, an Acid, and an Earth, combined together.

SUBDIVIS. I.

This Oil is found in the earth, has a peculiar taſte and ſmell, and is changed by the mineral Acids, and by heterogeneous Bodies, into the Genera of this Diviſion. The firſt is odoriferous, and limpid like water, inflammable like ether, and like it, extracts gold from aqua regia. The ſecond is of a brown colour, and has various degrees of denſity, according to the time of its expoſure to the Air. The third is like Tar, and is commonly called Barbadoes Tar, from the place in which it is found. The fourth breaks with a ſhining ſurface, is eaſily melted, and when pure, burns without leaving any aſhes. The fifth is of a glaſſy black colour, and is ſuſceptible of a good poliſh. The ſixth is Pitcoal. The ſeventh is Peat, and Turf. The eighth is Electrum, Succinum, Amber, Bernſtein, or Karabé. It is found in maſſes of different ſizes in the ſea, in various parts of the earth, and in the greateſt plenty in Pruſſia. The laſt is of a greyiſh colour, a fragrant ſmell, and is commonly found floating in the Ocean. The laſt four are ſuppoſed to have had their origin in the vegetable and animal kingdoms. The firſt of them, to be Timber; the ſecond, ſmall Vegetables; the third, vegetable Oils; which have been changed by mineral Bodies; and, the fourth is thought to be particular parts of the Whale, and of the Honey and Combs of Bees changed by Sea Water.

SUBDIVIS. 2.

The Oil procured from vegetables is changed by mineral Acids, and heterogeneous Bodies, into the Genera of this Subdiviſion. The firſt, which is got by preſſure, is not volatile in the heat of boiling water; is inſipid, and inodorous; is not ſoluble in ardent Spirits, but eaſily in eſſential Oils. The ſecond is procured by a heat leſs than that of boiling water, in which it is entirely volatile; it has the ſmell and taſte of the vegetables from which it is drawn.

The other parts of Vegetables belong to the other Diviſions of Matter, as Earths, Acids, Alkalis; and ſometimes when compounded have peculiar Properties.

SUBDIVIS. 3.

Oil got from the Bodies of Animals, which is eaſily diſtinguiſhed from Foſſil and Vegetable Oils, by its ſmell when burning. The firſt Genus is procured from particular parts of Animals, and contains an Acid that may be ſeparated by Fire, or, by the rancidity which it acquires from Time. The ſecond may be obtained from moſt of the parts of Animal Bodies; it contains a little Alkali.

Expreſſed and Eſſential Oils may be made Empyreumatic, by giving them greater degrees of Fire than are neceſſary for obtaining the Eſſential.

The other parts of animal Bodies belong to the other Diviſions of Matter; and ſometimes, when compounded, have peculiar Properties.

ORDER IV.

Fulminating Powders burn by the application of Fire; the laſt of the Genera even by Friction; and are ſuddenly converted into elaſtic fluids. That which is got from Gun-Powder, conſiſts moſtly of Pure, and of Mephitic Air; the firſt being nearly in proportion to the ſecond as 3 to 1.

ORDER V.

Phoſphori will not only ſhine in the dark, but take fire by the application of Common Air.

NOCTILUCAE,

Are bodies which are luminous in the dark, but do not take fire by expoſure to the Air. Some of them are electrical; and excepting them, it is probable that all of them burn and conſume, though ſlowly: this, however, is not yet aſcertained, and, therefore, they cannot be placed among the inflammables. They may be claſſed, according to the three kingdoms of Nature, in the following manner.

Lapis Bononienſis. Selenites. Fluor. Terra Calcarea, et Acidum Nitri. Sal Am. Fixum, et Calx Viva. Sulphur et Calx Viva. Multa Corpora in Fuſione. Nonnulli Lapides Colliſione. Adamas Luce Saturatus.

Lignum Putridum. Folia Nonnulla. Effluviae Nonnullae.

Piſces Putridae. Caro Putrida. Panni Nonnulli. Inſectae Marinae. Cicindela. Occuli Anim. Nonnullorum.

CLASS V.

Bodies which are fuſible, and return to their former texture when cold; which are bright when broken, or poliſhed; and which are found in the earth, combined with a grea t variety of bodies.

DIVISION I.

Metallic Bodies which are malleable, or extend under the Hammer. They are diſtinguiſhed into Perfect, and Imperfect. The firſt ſuffer no change from the joint effect of the air and fire in the hotteſt furnace. The laſt are unaltered by the ſtrongeſt furnace-fire when the air is excluded; but, in open veſſels, are changed into an earth that has no metallic Properties.

GENUS I.

Has a bright yellow colour; is in Specific Gravity 19,64; is of all bodies the moſt ductile; has little elaſticity; is almoſt as ſoft as lead; is eaſily united to quickſilver; ſtands the effect of air, water, and the greateſt furnace-heat unchanged; is diſſolved by aqua regia; precipitated by volatile alkali, and nitrous acid; and retains its ductility, though alloyed with a ſmall proportion of Silver, Platina, Copper, or Zinc.

GENUS II.

Is diſtinguiſhed from gold by the following properties; its colour is white; its Specific Gravity, when unmixed, is 17; when mixed with certain metals is 22; is harder and leſs coherent than gold; when mixed with other metals, or ſemimetals, is eaſily fuſed, but, when pure, with the utmoſt difficulty; by the muriatic acid it unites with quickſilver; is diſſolved in aqua regia; is precipitated with tin; and yields not the mineral purple.

GENUS III.

This body is a metal, becauſe it is malleable; though it is only ſo, when the cold to which it is expoſed is more than 72° below the freezing of Water; it is white, with a luſtre like poliſhed ſteel; its Specific Gravity is 14; though it eaſily exhales into ſubtile penetrating fumes, and is convertible, by a common furnace-fire, into the appearance of a calx, yet it is not decompoſed; it unites with all the metals, and ſemi-metals, except cobalt, and nickel; it diſſolves in the nitrous acid, and in the vitriolic by boiling; is precipitated by an alkali; is not affected by the muriatic acid, unleſs previouſly diſſolved by other acids; and unites with ſulphur by grinding.

GENUS IV.

Its colour, when pure, is a ſhining white; its Specific Gravity 11,091; it is ductile, though not ſo much ſo as gold; unalterable in pure air, or water; may be diſſolved by the nitrous acid, and in the vitriolic when boiling; if precipitated from the acid of nitre by common ſalt, or its acid, unites ſo ſtrongly with the muriatic acid, that it melts with it into a maſs like glaſs; it does not unite with nickel by fuſion; it unites eaſily with quickſilver; is acted upon by hepar ſulphuris; imbibes the fumes of ſulphur; is exhaled by volatile metals, and acids; and melts more eaſily than copper.

GENUS V.

Copper has a reddiſh colour; is in Specific Gravity 9, when of the fineſt kind; is ductile and ſoft; its calx, when diſſolved by acids, is green, and by alkaline ſalts is blue; it is eaſily calcined in the fire into a blackiſh ſubſtance, which becomes red by friction; when melted with glaſs, it firſt acquires a reddiſh brown colour, and afterwards a tranſparent green; it is ſoluble in all the acids, and in all alkaline ſolutions; it can be precipitated in a metallic ſtate; is not eaſily united with quickſilver; unites ſtrongly with zinc, and tin, and the compoſition is braſs, bell-metal, and various other bodies, which are commonly called Metals, with the addition of the Artiſt's name.

GENUS VI.

The colour of Iron is well known, when poliſhed, and unpoliſhed; its Specific Gravity, when of the fineſt kind, is 8; it becomes magnetical; it grows ductile by hammering, and by being often heated in the fire; it is diſſolved by all ſaline bodies, and their effluvia; it calcines eaſily into a black calx, which, when pounded, is of a deep red colour, and which may be diſſolved by the muriatic acid, and aqua regia; its calx, in a great quantity, gives a black colour to glaſs; and, in a ſmall quantity, a green. There are three ſorts of iron in common uſe, Caſt Iron, Forged Iron, and Steel, which have various names, according to their qualities.

GENUS VII.

Tin is of a greyiſh Colour; is in Specific Gravity 7,4; is the moſt fuſible of all the metals, and the leaſt ductile; has a peculiar ſmell; is eaſily calcined to white aſhes, which become a fourth part heavier than the metal, and eaſily mix in glaſs compoſitions; it unites with all metals, and ſemimetals, and renders them brittle, except lead, biſmuth, and zinc; it eaſily unites with quickſilver; diſſolves in the vitriolic, and muriatic acids, and in aqua regia; but is only corroded into a white powder by the nitrous; it is gradually corroded by the vegetable acid, by ſoaps, and pure alkalis; it diſſolves in aqua regia; and heightens the colour of cochineal.

GENUS VIII.

Lead, when freſh broken, or cut, is of a bluiſh white; but turns blackiſh in the air; its Specific Gravity is 11,325; it eaſily burns to a calx; which, according to the degree of fire, is white, yellow, or red; its calx melts to a glaſs more eaſily than any other metallic calx; and ſerves to bring other bodies, and the imperfect metals, into fuſion; it diſſolves in the vitriolic acid, in the nitrous, and in the vegetable, in alkaline ſolutions, and expreſſed oils; it gives a ſweet taſte to ſolutions; unites with quickſilver; has the ſame effect as ſilver with the muriatic acid; does not unite with iron, when joined to it in the fire, without ſome other addition; melts before it is red hot; and its calx may be reſtored to the metallic ſtate, by the vegetable fixed alkali.

DIVISION II.

Metallic bodies which are malleable, in a very ſmall degree compared to metals; and which loſe their metallic properties, in a certain degree of fire.

GENUS I.

Biſmuth is of a pale yellow colour, and laminated texture; is ſoft under the hammer, and yet brittle; in Specific Gravity is 9,7; it diſſolves in aqua fortis, without imparting any colour, but to aqua regia gives red; it eaſily unites with quickſilver; mixes with all metallic bodies, except cobalt and zinc, and the compoſition is white and brittle; is ſpeedily fuſed; and is volatile in the fire; its glaſs is of a yellowiſh brown colour.

GENUS II.

Kupfer Nickel is cloſe in its texture; its fractures are of a ſhining white colour inclining to red; its

Specific Gravity is 8,5; it calcines into a green calx, which tinges glaſs with a tranſparent reddiſh brown colour; it eaſily diſſolves in aqua fortis, aqua regia, and in the marine acid, but with more difficulty in the vitriolic, tinging all theſe ſolutions with a deep green; it eaſily unites with ſulphur, and forms with it a regulus; it unites with all the metals except quickſilver, and ſilver; to the laſt it only adheres; it requires near the ſame degree of heat with gold, to bring it into fuſion.

GENUS III.

Zinc, in colour, reſembles lead, but is not tarniſhed ſo quickly by the air; it ſeems to be compoſed of flat pyramids; its Specific Gravity is 7, when of the pureſt kind; it unites with all the metals except biſmuth, and makes them volatile; it eaſily incorporates with gold, or copper, and to the laſt gives a yellow colour; it is diſſolved by all the acids; unites with quickſilver more eaſily than with copper; melts in the fire before it has acquired a glowing heat, after which it burns with a flame of a changeable colour.

GENUS IV.

The Regulus of Antimony has a white colour, like ſilver; its Specific Gravity is 7,5; it breaks into long ſhining planes; is volatile in the fire, and carries off part of other metals when mixed with it, except gold, and platina; it has a grey calx, which melts into a glaſs of a reddiſh colour; it diſſolves in the marine acid, and aqua regia, but is only corroded by the nitrous into a white calx; it unites with quickſilver by a particular preparation; has an emetic quality, when its calx, glaſs, or metal, is diſſolved in an acid, except the nitrous.

GENUS. V.

Regulus of Arſenic, when newly broken, reſembles lead in its colour, but changes ſoon to yellow, and afterwards to black; its fractures have a laminated appearance; its Specific Gravity is 8; it diſſolves in the nitrous acid; unites with all metals; and is found mineralized; is volatile in the fire; and ſmells like garlic; is very difficult to be reduced, unleſs mixed with other metals; its calx eaſily melts to a glaſs, the Specific Gravity of which is about 5; and, when mixed with ſulphur, becomes of a yellow, orange, or red colour; its calx and glaſs are ſoluble in water, and in moſt liquids, but not with the ſame facility; it is poiſonous, eſpecially in the form of a pure calx, or glaſs.

GENUS VI.

Cobalt when made into a Regulus is of a greyiſh colour; and of a fine grained texture, like tempered ſteel; its Specific Gravity is 6; it gives a red ſolution in the vitriolic, and nitrous acids, and in aqua regia; is fixed in the fire, and becomes black by calcination; gives to glaſs an excellent blue colour, inclining to violet; its calx is diſſolved in the vitriolic, nitrous, and muriatic acids, in aqua regia, and by the volatile alkali; it is red when united with the calx of arſenic in a calcining heat; it does not unite with quickſilver, nor incorporate with biſmuth by fuſion, without an addition of ſome other body.

GENUS VII.

The Specific Gravity of Siderite is 6,71; its texture is granular; and its colour grey; it is not magnetical in ſmall pieces, but ſlightly ſo when powdered; it fuſes in nearly the ſame heat with copper; it is hardly ſoluble in any acid without the aſſiſtance of fire; it precipitates gold, ſilver, and copper in their metallic form, but, lead from the nitrous, in the form of a calx; it does not unite with ſulphur, nor form an amalgam with mercury; but, when in fuſion, unites with iron, copper, or cobalt; and it affects the quality of iron, according to the proportion of its mixture.

GENUS VIII.

From Manganeſe, a regulus is formed, which is of a duſky white colour, and an irregular ſurface; it is bright when freſh broken, but ſoon tarniſhes in the air; it is harder than iron, not ſo fuſible, and its Specific Gravity is 6,85; when expoſed to moiſt air it crumbles into a blackiſh powder; it is ſoluble in acids, and moſt readily in the nitrous.

GENUS IX.

Molybdena is, in Specific Gravity, about 4,569; it is only acted upon by the nitrous, or arſenical acids; its other metallic properties are imperfectly known.

From the Tungſten Acid, a regulus is formed, which with alkalies, gives ſalts that may be cryſtalized; and, in ſome lead mines, an ore is found which ſeems to yield another ſemi-metal; but their characters are imperfectly known.

DIVISION III.

Metallic foſſils, or metallic bodies as found in the earth.

SUBDIVIS. 1.

Metals as found in mines; either pure, or united to foſſils.

SUBDIVIS. 2.

Semi-Metals, as found in the earth.

CLASS VI.

A well known body, which is fluid, or ſolid, in different degrees of cold; which is volatile by fire; and not inflammable.

ORDER I.

Is without taſte, and colour, and its weight to gold of the ſame bulk is as 1 to 19,64; it grows ſolid when the thermometer is at 32°, and boils in the open air, when it is at 212°, the barometer being about 30; it diſſolves acids, alkalies, and neutral ſalts, and only a certain quantity of each; and, when heated, diſſolves and ſuſtains a greater quantity than when cold; it has no effect in diſſolving any metallic ſubſtance, except arſenic, unleſs impregnated with an acid, an alkali, or neutral ſalt, and then it becomes a menſtruum for ſuch metallic ſubſtances as theſe ſalts diſſolve. If incloſed in a globe of gold, it may be forced by preſſure through the pores of the gold; and, without making any fiſſure, will appear on the outſide, in the form of dew. It is only ſimple when no art is uſed to annalize it; for it ſeems to be compoſed of Pure Air, and Phlogiſton, combined in an unknown manner.

ORDER II.

Is water found on the ſurface, or in the bowels of the earth, in which various bodies are diſſolved, and ſuſpended; the diviſions and genera of which are ſufficiently plain, from their names and the characters already given.

CLASS VII.

Particles of matter inconceivably ſubtile, which give the ſenſations of heat, and light, ſeparately, or in conjunction; which ſometimes are in a fixed, and ſometimes in a moving ſtate; and the effects of which are different, according to the nature of the bodies in which they are fixed, and by which they are ſurrounded when decompoſed.

The firſt genus is fire, when at reſt in a body, and in ſuch a quantity that it neither affects our ſenſes, nor a thermometer; but is capable of affecting both, when diſlodged by friction, or percuſſion, or the decompoſition of the body. The ſecond is fire, when it excites the ſenſation of heat, or affects the thermometer, but gives no light, and moves in all directions. The third is fire, when it is in a certain quantity, and moves in ſtraight lines, and excites the ſenſation which we have when we ſay, I ſee; and then it is the ſubject of Optics. The fourth is fire, when it gives the ſenſation of heat, and light, at the ſame time.

Though the nature of fire, as diſtinguiſhed from its effects, which are afterwards conſidered, is very imperfectly known; yet it is the great agent by which the operations of nature, and art, are conſtantly carried on.

SECT. VIII.

OF CORPUSCULAR ATTRACTION.

PROP. I.

A power, called by this name, unites the particles of the ſame fluid; as the particles of water, the particles of quickſilver, the particles of melted lead.

COR. 1. Hence the particles of theſe fluids form drops which are ſpherical; and more ſo, the leſs they are in ſize.

COR. 2. According to the force with which this power acts, theſe bodies are fluid or ſolid, or hard, or ſoft.

PROP. II.

The particles of many different fluids may be united by this power, and formed into one compound; as the particles of water and air, of water and alcohol, of water and the vitriolic acid, of quickſilver and the nitrous acid. On the other hand, when two or more fluids are joined together, and when the attraction among their reſpective particles is greater than the attraction between the fluids themſelves, there will be an appoſition, juxtapoſition, or mixture of the fluids, bnt no ſolution.

PROP. III.

By the ſame power the particles of many fluids adhere to ſolids, and form one maſs, without decompoſing the ſolid; as water and wood, water and glaſs, oil and glaſs.

Cor. When the particles of fluids adhere to ſolids, and are ſuſpended, they form drops, which adhere, or fall, according to their weight, and the force of this power.

PROP. IV.

The attraction is not the ſame between the ſame ſolid and different fluids; as, for inſtance, between the ſame piece of glaſs and oil, and water, and alcohol; nor between the ſame fluid, and different ſolids, as, for inſtance, between quickſilver and gold, ſilver, tin, lead, biſmuth, zinc, copper, reg. of antimony, iron, and cobalt; the relative attractions of which bodies with quickſilver, being as the following numbers, 446. 429. 418. 397. 372. 204. 142. 126. 115. 8.

Cor. Hence drops, formed by the adheſion of different fluids to the ſame ſolid, are different in weight; as well as drops formed by the adheſion of the ſame fluid, to different ſolids.

PROP. V.

Water will riſe in glaſs capillary tubes above its level, and be ſuſpended, at heights which are reciprocally as the diameters of the tubes. And, if a veſſel of any ſhape or ſize has its upper part drawn into a capillary tube, if it is filled with water, and inverted in a baſon of water, the whole quantity of water inverted will be ſuſpended in the veſſel and tube; provided the height of both does not exceed the height from the ſurface of the water in the baſon, to which a capillary tube of the ſame diameter would raiſe it.

Cor. 1. Water may be drawn out of a veſſel by a capillary ſyphon, provided the height of its curvature, above the ſurface of the water, is leſs than the height to which the water will riſe in a tube of that diameter.

Cor. 2. Oil riſes in cotton; water in paper, bread, ſugar, earth, ſpunge, linen, and woollen cloth.

Cor. 3. Hence the uſe of filters, of various kinds, for ſeparating fluids from mixtures, and ſediments.

PROP. VI.

There is an attraction between the particles of quickſilver and glaſs, but not ſo great as between the particles of quickſilver themſelves. The ſame thing is true, but with different degrees of force, between iron and quickſilver, wood and quickſilver, and many other bodies.

Cor. 1. Hence quickſilver will not adhere to iron, wood, or glaſs, nor riſe in capillary tubes made of them; but it will adhere to gold, ſilver, or braſs; will riſe in capillary tubes made of them, and even enter their pores.

Cor. 2. For the ſame reaſon, water will not adhere to a body that is varniſhed, nor riſe in a capillary tube that is made of gum, nor in one of glaſs that is coated with oil.

PROP. VII.

When a fluid is applied to a ſolid, with the particles of which, it has a greater attraction than they have with each other, the particles of the ſolid will be decompoſed, and diffuſed through every part of the fluid; and only a certain quantity will be ſuſpended, according to the temperature, and attraction of the bodies.

Cor. 1. Hence the ſolution of ſugar in water, and not in oil of turpentine; of gums in alcohol, and not in water; and of metals in acids, and not in water, nor in alcohol; and hence the difference between mixtures and compounds.

PROP. VIII.

Solid bodies will cohere by this attraction; as pieces of marble, glaſs, wood, lead, ſilver; pieces of marble and glaſs, glaſs and wood, wood and lead, lead and ſilver. And, when the particles of ſolids cannot be brought ſufficiently near to each other, for the corpuſcular attraction to act, or, when the attraction between the bodies is not ſufficient to make them cohere, they may be made to cohere by the interpoſition of a third body, which can ſupply both, or either of theſe defects.

PROP. IX.

Corpuſcular attraction is not cauſed by the preſſure of the atmoſphere; it reaches not to the diſtance of half an inch; it acts not according to the quantities of matter in the attracting bodies; it is mutual and equal among the particles of the ſame fluid; and it ſeems to decreaſe in the duplicate ratio, or as the ſquares, of the diſtances. But, between different fluids, it is difficult to aſcertain the law of this attraction, on account of the minuteneſs of the parts, the uncertainty of their weight, and their relative degrees of attraction.

SECT. IX.

OF ELECTIVE ATTRACTION.

PROP. I.

There is a corpuſcular affinity, or elective attraction, as it is called, among the particles of matter; that is, a given body is attracted by many other bodies, but more readily, and more ſtrongly, by one of them than by another.

PROP. II.

When a given body is attracted by ſeveral bodies, a great number of ſuch bodies may often be united with it at the ſame time. But, in many caſes, though a body may be united with ſeveral bodies when taken ſeparately, it can be united but with one of them at the ſame time; and hence a ſucceſſion of precipitations, and ſolutions may be made.

PROP III.

Two bodies which do not attract each other, ſo as to make a ſolution, may be made to attract, and to unite together by the interpoſition of a third body, which attracts one of them, and unites with it.

PROP. IV.

If a body is compounded of two parts, and a third body is applied to it which attracts one of theſe parts and not the other, and at the ſame time attracts that part more ſtrongly than they do each other, a decompoſition will enſue; the parts of the compound will be ſeparated from each other, and one of them will form a new compound with the body applied.

PROP. V.

When a compound conſiſts of two parts, and a third body is applied to it, which, though it may be united with either of theſe parts, is more ſtrongly attracted by one of them than by the other, while, at the ſame time, it attracts that part more ſtrongly than the two parts do each other, a decompoſition of the compound will enſue, and a new compound will be formed of one part of the compound and of the body applied.

PROP. VI.

A body, which of itſelf cannot decompoſe a compound conſiſting of two parts, becauſe of the ſtronger attraction between theſe parts, will decompoſe them, if it is combined with another body which has a force of attraction to one part of the compound that compenſates the defect of its own attraction to the other part; and, in ſuch caſes, a double decompoſition, and a double combination will enſue.

Cor. 1. Hence, the table of Affinities which have been formed by chymiſts; and from which it appears, that coheſion and ſolution proceed from the ſame cauſe.

SECT. X.

OF THE COHESION OF BODIES.

PROP. I.

The coheſion of fluids, rain-water being the ſtandard, and 60 the degree of heat, is, at a medium, in proportional numbers, as follows:

Alcohol.	16	Cow's Milk.	38
Oil of Olives.	20	Rain-water.	50
Oil of Saſſafras.	21	Sea-water.	56
Oil of Vitriol.	34	Quickſilver.	64
Ale.	36	&c.	

PROP. II.

The abſolute coheſion of flexible cylindric ſolids, of one tenth of an inch in diameter, is, at a medium, as follows:

	℔		℔
Raw Lint.	37	Raw Hemp.	46
Horſe-hair.	45	Raw Silk.	53½, &c.

PROP. III.

The abſolute coheſion of cylindric pieces of wood, of one tenth of an inch in diameter, is, at a medium, as follows:

	℔		℔
Fir.	23	Oak.	48
Elm.	35	Beech.	50
Alder.	40	Aſh.	50, &c.

PROP. IV.

The abſolute coheſion of cylindric pieces of metal, of one tenth of an inch in diameter, is, at a medium, as follows:

	℔		℔
Zinc.	18	Braſs.	360
Lead.	$29\frac{1}{4}$	Silver.	370
Tin.	$40\frac{1}{2}$	Iron.	450
Copper.	299	Gold.	500

Of the uſefulneſs of ſuch experiments; and, of the variations which take place in making them.

SECT. XI.

OF CORPUSCULAR REPULSION.

PROP. I.

If the vapours of the nitrous, and marine acids are mixed together, they will become much more expanſive, and difficult to be confined, than when they were ſeparate.

PROP. II.

There is a repulſion between the particles of certain fluids, though not in a ſtate of evaporation; as, between water and oils, when reſting upon ſolids, or upon fluids, and, when of very unequal Specific Gravities; as, between water and melted copper; while there is no ſuch effect between water, and gold, or ſilver, when in the ſame degree of heat.

PROP. III.

In a certain temperature, the particles of all fluids repel each other; and the particles of metals, and of many other bodies.

PROP. IV.

When the particles of water, air, and fire are mixed together, ſo as to make ſteam, they repel each other with a great force, which is ſuddenly deſtroyed by cold.

COR. Hence, the effect of glaſs bombs, and the eolipile; and, the importance of keeping moiſture out of moulds for metals.

PROP. V.

Among the particles of the atmoſphere, and among the particles of factitious air, there is a great repulſion; and in every degree of cold.

PROP. VI.

In every temperature, the particles of elaſtic bodies repel each other, under certain preſſures.

PROP. VII.

Some fluids, and ſolids repel each other; as, water and the leaves of plants, gums, and camels hair; water and poliſhed ſteel, ſilver and gold, which, in ſmall poliſhed maſſes, will float upon it, and ſwim, when immerſed, though their Specific Gravity is much greater.

PROP. VIII.

There is a repulſion between the particles of certain ſolids; as, between the ſurfaces of poliſhed pieces of ſteel; and, between the ſurfaces of poliſhed convex glaſſes.

PROP. IX.

When the ſurfaces of glaſs tears, and the ſurfaces of elliptical glaſs phials are broken, their internal particles burſt aſunder with great violence.

PROP. X.

Corpuſcular repulſion ſeems to reach to as ſmall a diſtance as corpuſcular attraction; to be unaffected by the quantity of matter; to decreaſe in the duplicate ratio of the diſtances of the repelling bodies; and, to begin at the limits of the ſphere of attraction; but, it is ſtill more difficult to aſcertain this law, than that of corpuſcular attraction, and for the ſame reaſons.

SECT. XII.

OF FIRE.

DIVIS. I.

OF THE SENSATIONS PRODUCED BY FIRE.

PROP. I.

When fire acts upon the human body, in a certain quantity, it produces the ſenſation called heat; and, when that quantity is diminiſhed, there ariſes the ſenſation named cold. By increaſing, or diminiſhing, that quantity, theſe ſenſations may be increaſed, or diminiſhed, in various degrees; to denote which, different words are uſed.

PROP. II.

In eſtimating the preſence, or abſence of fire, that is, heat and cold, by the feeling, the judgment is according to the temperature of the parts of the body that are applied. But, if the ſame part is aprepel each other; and the particles of metals, and of many other bodies.

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PROP. III.

When fire is modified in a particular manner, and moves in ſtraight lines in a certain quantity, it is called Light; and the ſenſation which it produces by entering the eye, is called ſeeing.

Cor. As there may be heat, and no ſenſible light; ſo there may be light, and no ſenſible heat; but, whether this is only relative to the human ſenſes, is not certainly known.

DIVIS. 2.

OF THE ATTRACTION OF FIRE.

PROP. IV.

Bodies expoſed to heating and cooling mediums gain or loſe, in equal times, quantities of fire proportioned to the temperature in the hotter body.

Cor. 1. When the exceſs is conſtant, equal quantities are gained, or loſt in equal times.

Cor. 2. There is, after a certain time, the ſame heat, that is, power of exciting heat, in an air-pump vacuum, and in the adjoining air, water, wood, and metals.

PROP. V.

The more remote a cold body is from a hot one, the leſs it is heated, and in the duplicate ratio of the diſtances.

PROP. VI.

Bodies of the ſame kind of matter receive fire, or are heated, in proportion to their ſurfaces, all circumſtances being equal; and they retain it, or cool, in proportion to their quantities of matter.

PROP. VII.

Metallic bodies, by being reduced to a calx, are increaſed in their weight.

In an open veſſel, one hundred pounds of lead, when calcined in a furnace, is increaſed to one hundred and ten pounds. One pound of zinc acquires two drams and an half. Biſmuth is increaſed one forty-eight part. And tin, one twelfth.

In a cloſe veſſel, an ounce of tin, calcined in the furnace, acquires four grains and an half; an ounce of copper, forty-nine grains; and, an ounce of antimony, two drams.

In the focus of a burning glaſs, one pound of regulus of antimony, when calcined, acquires a tenth part more; and a ſimilar effect is produced upon many other metallic bodies.

PROP. VIII.

When a metal is diſſolved in an acid, the mixture is heavier than the ſum of the weights of the metal and acid; and, when a metal is diſſolved in an acid, and precipitated by a cauſtic fixed alkali, the calx is heavier than the metal; fire, as well as air, being attracted during theſe operations.

DIVIS. 3.

OF THE ELECTIVE ATTRACTION OF FIRE.

PROP. IX.

Many bodies, though of the ſame temperature, of the ſame bulk, of the ſame ſhape, and equally expoſed to the ſame degree of fire, do not attract equal quantities of it in the ſame time; as, for inſtance, the different kinds of woods; and, metals compared to wood, and to one another.

The celerity with which the following fluids attract fire is according to this order; air, mercury, petroleum, oil of turpentine, alcohol, ſpirit of wine, vinegar, oil of vitriol, water, animal juice, white wine, milk, ſalt-water, aqua fortis, lintſeed oil, olive oil.

PROP. X.

All circumſtances being equal, this is the order in which the following bodies are deprived of their fire, or cool; air, mercury, alcohol, oil of turpentine, water, petroleum, oil of vitriol.

PROP. XI.

Bodies of the ſame kind, but of different colours, attract different degrees of fire in the ſame time, and in this order; black, purple, blue, green, yellow, red, white; the firſt being moſt heated.

Cor. Hence, the effect of colour in utenſils, cloaths, and garden walls.

PROP. XII.

If a porcelain cup is filled with water, and fixed in the mouth of a metallic veſſel, which is likewiſe filled with water, and made to boil upon the fire, the heat of the water in the veſſel will be greater than that in the cup. If, inſtead of the porcelain cup, different metallic ones are uſed, the heat of the water in the cups will ſtill be leſs than that in the veſſel, though not in the ſame proportion.

Cor. Hence various methods of preventing the communication of fire to adjoining veſſels, and of regulating its temperature; and hence methods of making houſes leſs ſubject to be burnt.

PROP. XIII.

The ſun's rays, collected in a great quantity, will inflame combuſtible matter placed in water, while the water will only acquire a ſmall degree of heat.

PROP. XIV.

If maſſes of metals, earths, woods, or fluids in veſſels, are incloſed in wrappers of wool, cloth, ſkins, hair, or feathers, their heat will be preſerved longer than if they were incloſed by air, or water, to the ſame extent with theſe wrappers.

Cor. Hence the effect of covering up ſnow, ice, plants; and of cloathing of different kinds to animal bodies.

PROP. XV.

Hot water cools ſooner in vacuo than in the air, hot iron more ſlowly; chalk is ſlow in heating, and loſes its heat very ſoon.

PROP. XVI.

A body which attracts fire ſlowly, or in a ſmall quantity, may be made to attract it quickly, and in a larger quantity, by its union with a third body.

DIVIS. 4.

OF THE REPULSION OF FIRE.

PROP. XVII.

Fire is repelled by certain bodies; by ſuch, for inſtance, as are white, and by poliſhed metals; and it, ſometimes, has fits of attraction, and repulſion, among the particles of the ſame body.

DIVIS. 5.

OF THE EXPANSION OF FLUIDS BY FIRE.

PROP. XVIII.

All fluids are dilated by fire, but the dilatation is not according to their denſities or coheſions; perhaps it is in a ratio compounded of both, and of their elective attractions. The following fluids dilate, and contract, with different degrees of celerity, according to the order in which they ſtand; air, mercury, alcohol, oil of turpentine, water, petroleum, oil of vitriol.

PROP. XIX.

As ſoon as a fluid is made to boil, it is, if in the open air, in the ſtate of its greateſt expanſion.

PROP. XX.

Bodies, when in a fluid ſtate, are, in general, leſs denſe than when in a ſolid; but, frozen water is not commonly ſo, on account of the air with which it is mixed. The force with which it expands is ſo great, as to overcome the coheſion of the ſtrongeſt iron veſſels, and to raiſe up the greateſt maſs of building.

Cor. Hence the deſtructive effects of water lodged in trees, walls, or rocks, during a great froſt, even in temperate climates.

PROP. XXI.

From the degree of heat at which water freezes, to the degree at which it boils, the following bodies are increaſed in bulk in this proportion; lintſeed oil, ſeventy-two parts of a thouſand; ſpirit of wine, eighty-ſeven; and mercury, fourteen.

PROP. XXII.

Water increaſes in bulk one eighty-fifth part, from the degree of heat at which it freezes, to the degree of heat at which it boils; alcohol increaſes one ninth part, from the degree of heat at which water freezes, to the degree of heat at which alcohol boils; mercury increaſes four parts of fifty-one from the degree of heat at which water freezes, to the degree of heat at which mercury boils; and, mercury is leſſened in bulk one tenth part, from its boiling, to its freezing point.

PROP. XXIII.

Common iron, but not fine ſteel, when fully liquified, is more denſe than when ſolid; as ſoon, however, as it is ſolid, it decreaſes in denſity, till it is cold.

DIVIS. 6.

OF THE EXPANSION OF SOLIDS BY FIRE.

PROP. XXIV.

Many ſolid bodies, ſuch as glaſs and metals, are dilated by fire, and not in the direct ratio of their denſities, nor the inverſe of their coheſions.

Cor. Hence, and from Prop. IV. if a fluid is put into a glaſs-tube, the fluid will ſink when the tube is firſt immerſed in hot water.

A Table of the expanſion of ſome metals; ſhewing how much a foot in length in each, grows longer by an increaſe of heat correſponding to 180°, expreſſed in parts, the unit of which is equal to the 10,000th part of an inch.

Barometer Tube	100	Braſs wire	232
Hard Steel	147	Speculum metal	232
Iron	151	Fine Pewter	274
Biſmuth	167	Zinc, hammered	323
Copper, hammered	204	Lead	344
Caſt Braſs	225	Zinc, or Spelter	353

Of the variations in making ſuch experiments, owing to the different degrees of purity, or to the hammering of the metals.

DIVIS. 7.

OF THE CONTRACTION OF SOLIDS BY FIRE.

PROP. XXV.

Though moſt foſſil bodies dilate upon the application of fire, there are ſome which do not alter in ſize, and others which contract. Flints, and quartz are diminiſhed very little; jaſper is diminiſhed a fourth part; and, ſome clays, that are compounds of ſiliceous and alum earth, ſtill more; and their contractions are regular, according to the degree of heat.

PROP. XXVI.

Vegetable bodies are contracted by fire, in various degrees, according to the water, or reſins, which they contain. Some contract very little, if cut longitudinally, but are apt to warp, unleſs in large maſſes, or ſecured from moiſture.

PROP. XXVII.

Moſt animal ſubſtances are contracted by fire; but ſome, ſuch as ivory, whale-bone, ox-horn, cat-gut, ſilk-ſtrings, dilate, or contract, and unequally, according to a variety of circumſtances.

Of the cracking or ſplitting of bodies by fire.

DIVIS. 8.

OF THERMOMETERS.

Of the conſtruction, advantages, and diſadvantages of the air-thermometer; of the thermometer made by the Florentine Academy; by the Royal Society; by the Academy of Sciences; by Newton; by Fahrenheit; by Reaumeur; by De L'Iſle; and by others.

PROP. XXVIII.

In Fahrenheit's thermometer, the freezing of water is marked 32°, and its boiling, 212°; human heat, 96°; the boiling of Mercury, 600°; the cold produced by a common mixture of ſnow and ſal ammoniac, 0; and, the greateſt artificial cold which he was able to produce, 40° below 0.

Though it had been long ſuſpected that mercury freezes in a great degree of cold, yet, it was not till the year 1759 that this was aſcertained, by cooling mixtures made in Ruſſia, during a ſevere froſt; and it is now certain that it freezes at 40° below 0, by Fahrenheit's ſcale, or at 72° below the freezing of water. Hitherto, it has been found impoſſible to freeze pure alcohol; ſo that thermometers made of it are uſed in examining degrees of cold, greater than that by which quickſilver is frozen. This is the thermometrical ſcale that is commonly uſed in Holland, Britain, and ſeveral other countries.

PROP. XXIX.

In Newton's thermometer, 0 correſponds to 32 in Fahrenheit's; and 34, to 212; which degrees are ſubdivided into minute parts. In Reaumeur's thermometer, 0 correſponds to 32 in Fahrenheit's; 80, to 212; 250 above 0, to 600; and 187 below 0, to 390. In De L'Iſles thermometer, 0 correſponds to 212 above 0; about 152 below 0, to 32 above 0;

328 above 0, to 600 above 0; 469 below 0, to about 350 below 0; and 500 below 0, to 390 below 0.

DIVIS. 9.

OF PYROMETERS.

Of the conſtruction, advantages, and diſadvantages of the ſimple pyrometer; of the lever pyrometer; of the pyrometer made by Graham, Muſchenbroek, Ellicot, Smeaton, and others.

Of Wedgewood's clay-pyrometer; by which degrees of fire are accurately meaſured, from a low red heat to vitrification, through a ſcale of 160°, which connects with Fahrenheit's ſcale.

DIVIS. 10.

OF FUSION.

A table of the degrees of heat at which fuſion is produced in ſome bodies.

Tin at	408°	Fat of Veal	100°
Lead	504	Fat of Bullocks	104
Biſmuth	460	Fat of Sheep	124
Regulus Martis	805	Bees Wax	140
Iron	869	Spermaceti	180
Olive Oil	36	Honey	104
Fat of Hens	68	Pitch	186
Fat of Ducks	80	Reſins	240
Common Butter	88	Sulphur	244
Fat of Vipers	96	Bitumen	300

Of the variations which take place in making ſuch experiments, and of their uſe.

PROP. XXX.

A compoſition of lead, zinc, and biſmuth, in equal parts, may be kept in fuſion, when they have a degree of heat that will not ſinge paper. If lead, tin, and biſmuth are mixed in the proportion of one, four, five, they will melt at 246°. And, if a mixture is made of lead, tin, biſmuth, and mercury, their proportions being as two, three, five, one, it will melt with a heat leſs than that of boiling water.

PROP. XXXI.

The particles produced by flints ſtriking againſt ſteel, are commonly ſlices of the metal which are ſhrivelled up, or fuſed, or vitrified.

PROP. XXXII.

Some bodies cannot be reduced to fuſion by furnace-fire, or with difficulty; but, if another body is added to them, they may be eaſily fuſed.

PROP. XXXIII.

By collecting the rays of the ſun, heat has been increaſed ſo as to produce the following effects. Clay, ſand, marble, jaſper, porphyry, fire-ſtone, crucibles, flints, animal bodies, and pumice-ſtone were melted into glaſs; gems became friable; gold was vitrified, or diſſipated into ſmoke; aſbeſtus was turned into a yellow ſlag; copper-ore was turned into glaſs in eight ſeconds; a piece of Roman patera began to melt in three ſeconds, and, in fifty, a piece of the Alexandrian pillar was fully vitrified.

DIVIS. II.

OF THE EVAPORATION OF BODIES.

PROP. XXXIV.

The particles of all bodies, when in open veſſels, are diſſipated by the application of fire in a certain quantity. A ſmall degree of heat produces this effect in ſome, while the greateſt is neceſſary to produce it in others.

PROP. XXXV.

If a veſſel of water is placed where the air has but little motion, and its heat is 60°, it will evaporate about eight inches of its depth in one year; if it is kept at 80°, which is the ſame degree of heat with that of the air in a hot day in ſummer, it will evaporate about the ſixtieth part of an inch of its depth in two hours; if it is expoſed to a ſtrong wind, it will evaporate much more.

DIVIS. 12.

OF BOILING.

PROP. XXXVI.

All fluids, excepting air, that are homogeneous, and that exhale, without any ſeparation of their parts, may be made to boil by fire; and then they are as hot as they can be in the open air.

PROP. XXXVII.

If water is cloſely ſhut up, the heat may be increaſed ſo as to diſſolve bones, and to melt tin, and zinc. When the weight of the ſuperincumbent air is increaſed, water receives a greater degree, and when diminiſhed, a leſs degree of heat, before it boils.

Cor. 1. Water, that is not cloſely ſhut up, will boil ſooner or later in the ſame place, and with the ſame degree of fire, according to the weight of the air, or the height of the barometer.

Cor. 2. Hence the importance of obſerving that inſtrument when 212° is marked upon the thermometer; together with the height of the place above the level of the ſea.

PROP. XXXVIII.

While the air is of a mean weight, ether will boil at about 100°; alcohol at 176°; water at 212°; ſpirit of nitre at 242°; lixivium of tartar at 240°; oil of vitriol at 546°; lintſeed oil, and quickſilver at about 600°.

DIVIS. 13.

OF THE BURNING OF BODIES.

PROP. XXXIX.

Bodies may be decompoſed by burning; and common ſmoke, flame, and aſhes may be converted into each other.

Cor. Lamps, and furnaces may be conſtructed which will have no ſmoke.

Of lamps, and furnaces of different kinds; and the beſt methods of conſtructing them.

DIVIS. 14.

OF GENERATING COLD.

PROP. XL.

If a bottle of water, or wine, or ſpirits, is moiſtened on the outſide with water, from time to time, and is placed in a current of air, it will be deprived of its fire, or it will be cooled, according as the fire is carried off by the moiſture on the outſide; and, cold may be produced more ſpeedily, and to a greater degree, by a ſimilar evaporation of fluids that are more volatile than water; and by ether to 50° below the freezing of water.

Cor. 1. Liquors, and animal bodies may be cooled, in the hotteſt weather, and ice may be produced, by the evaporation of fluids.

Cor. 2. Hence the effect of fanning, of ſweating, and of currents of air to animal bodies

PROP. XLI.

Cold will enſue, and in various degrees, by mixing the vitriolic acid, greatly diluted, with nitre in a certain proportion, or with the volatile ſal urinae; by mixing aqua fortis with ſal ammoniac; the marine acid with antimony; the acetous with volatile alkaline ſalts; alcohol with ſal ammoniac, and moſt eſſential oils; and water with nitre, ſal ammoniac, common ſalt, and many ſaline bodies.

PROP. XLII.

If a veſſel containing water is ſet in ſnow, or pounded ice, with which is mingled common ſalt, as the ſnow, or ice melts away, the water will freeze in the veſſel; and, if a ſimilar apparatus is ſet upon the fire, when the ſalt and ſnow are liquified by the fire, the ſame effect will follow.

PROP. XLIII.

By mixing ſtrong ſpirit of nitre, with ſnow, or pounded ice, cold may be produced to 72° below the freezing of water.

PROP. XLIV.

Mercury freezes at 72° below the freezing of water, when placed among ice made in the above manner, or, when made with ſtrong vitriolic acid cooled artificially, while the temperature of the air is 40° or 50° below the freezing of water. By a ſimilar method cold may be increaſed to 384°; and to many hundred degrees ſtill lower, if credit may be given to ſome accounts of artificial mixtures.

DIVIS. 15.

OF GENERATING HEAT.

PROP. XLV.

Fire is excited, or heat is produced, by agitating thick oils in the air; by vegetable bodies, while they undergo the vinous fermentation; by animal and vegetable bodies, while they undergo the putrefactive fermentation; and, by cloths when laid up moiſt in heaps.

PROP. XLVI.

It is likewiſe produced, by mixing water, with quicklime; with the vitriolic acid and iron; and with the vitriolic acid in a certain temperature; by mixing the ſpirit of nitre with lead, tin, iron, copper; and, by combining many bodies, foſſil, vegetable, and animal, which act upon each other.

Cor. Pyrites take fire by the addition of a little water; and, by expoſure to the air.

PROP. XLVII.

When ſpiritus fumans nitri is added to oil of carraways, ſaſſafras, guiacum, camphor, pepper, or animal bones, an efferveſcence, and flame enſue.

PROP. XLVIII.

A mixture of aqua fortis, oil of vitriol, and oil of turpentine, their quantities being as two, one, three, will kindle into a flame.

PROP. XLIX.

If large and equal quantities of iron-filings, and powder of ſulphur are made into a paſte with water, they will, after ſome hours, break out into a flame, though covered up with earth.

Cor. The above facts ſhould be remembered when warehouſes, and magazines are filled.

PROP. L.

By attrition, heat and flame are produced; as, by the rubbing of ſticks, or ropes, or the parts of large machines, when a fluid is not interpoſed.

PROP. LI.

Fire is produced by percuſſion; as, by hammering a ſmall piece of iron, if it meets with reſiſtance, or, if it makes part of a large maſs; and, by colliſion, as by the ſtriking of flint againſt ſteel.

PROP. LII.

When phoſphorus is expoſed to the air, it will ſmoke, flame, and burn.

PROP. LIII.

By an aſſemblage of the ſun's rays, a fire may be produced which will diſſipate the firmeſt bodies; and yet the power which theſe rays have to produce that effect, increaſes in ſo high a ratio, that their heat, at the diſtance of two inches from the focus, does not equal that of boiling water.

Cor. Hence the effect of contracting the flame of a blow-pipe, and the flame of a furnace.

DIVIS. 16.

OF LATENT HEAT.

PROP. LIV.

Fire is often imbibed by bodies, and is in ſuch a quieſcent ſtate that it does not affect the thermometer, till the body is decompoſed, or its conſtitution is altered.

PROP. LV.

If one thermometer is put into a freezing mixture, and another over it, the firſt will ſink, and the other will riſe, as the freezing goes on; and, by the condenſation of ſteam, heat is generated.

PROP. LVI.

Unboiled water, if undiſturbed, may be cooled below the freezing point, and yet remain fluid; but, upon giving it a ſhake, it will freeze immediately; when boiled water, in the ſame circumſtances, is cooled to the freezing point, a part of it is immediately changed into ice; after which more ice is continually formed, till the whole is congealed.

PROP. LVII.

If a piece of ice is in a medium, which contains a greater quantity of fire than is neceſſary to melt it, the temperature of the ice will continue riſing till the ice begins to ſoften, and then its temperature will be ſtationary for about 150 times longer than the time which it took to riſe from 30° to 31°; at the end of which time, the ice will be perfectly fluid, and its temperature will become progreſſive, according to Prop. IV.

When a pound of water, the temperature of which is about 32°, is poured to an equal quantity of water which is at 212°, the temperature of the mixture will be 122°; but, if a pound of beaten ice is mixed with an equal quantity of water at 212°, the temperature of the mixture will be 47°.

PROP. LVIII.

If water, at a temperature ſeveral degrees higher than 32°, is expoſed to a medium conſiderably lower, when the water arrives at that temperature in which it can no longer remain fluid, it is ſtationary for near 150 times, the time ſpent in paſſing from 34° to 33°; but, when the water is perfectly frozen, it begins immediately to ſink in its temperature, as above mentioned.

When a ſolution of Glauber's ſalt is made at 180°, and kept at that temperature; if it is let cool, without being expoſed to agitation, it will cool without being cryſtallized; but, if it is quickly ſhaken, it will inſtantly cryſtallize; the thermometer at the ſame time riſing ſeveral degrees.

DIVIS. 17.

OF ANIMAL HEAT.

PROP. LIX.

The heat of the moſt inflammable foſſils, of the moſt flouriſhing vegetables, and of all dead bodies that are not putrifying, is the ſame with that of the bodies which ſurround them, as above explained in Divis. 2.

PROP. LX.

Inſects have but a ſmall degree of heat, above the air in which they live; but 96° is the heat of a ſwarm of bees. The heat of moſt fiſhes is nearly the ſame with the temperature of the water in which they ſwim; but that of the cetacea is 96°. From 100° to 108° is the heat of birds. From 100° to 103° is the heat of common quadrupeds. And 96° is the heat of a healthy man, whoſe mind is at eaſe, and body at reſt.

PROP. LXI.

Moſt inſects are killed by ſmall changes of heat, and cold, in the air, when they have no retreat from it. Though many of the large animals do not live in the open air, when far removed from their native climates; yet, ſome of them can bear great changes of heat and cold, when they have gone through previous gradations. Man can live not only in the temperate zones, but in polar regions, where the temperature of the air is below the freezing of quickſilver; and, not only in the hotteſt places of the torrid zone, but, in artificial heats, greater than that of boiling water.

Of the cauſe of animal heat. Of the powers in the animal economy, by which it reſiſts deſtructive degrees of heat and cold; and, of the beſt defences againſt both.

DIVIS. 18.

OF THE HEAT OF THE EARTH.

PROP. LXII.

On lofty mountains, every degree of temperature is experienced, from the heat of the torrid zone at their feet, to perpetual ſnows on their tops; the decreaſe of heat being in the proportion of one degree, for about 190 feet of perpendicular height, above the level of the ſea.

In Peru, vegetation ceaſes at the height of 14697 feet; on the Alps, at 9585 feet; and its limit varies in different latitudes.

In the heat of ſummer, water freezes under the Equator, at the perpendicular height of 15400 feet above the level of the ſea; in France, in latitude 45°, at the height of 6740 feet; but on none of the Britiſh mountains, they being all leſs than a mile in perpendicular height.

Cor. The ſun cannot be the cauſe of theſe unequal heats; as nearly an equal portion of his rays falls upon equal ſpaces of the vallies, and mountains.

PROP. LXIII.

The temperature of natural fountains, near the level of the ſea, is about 48°; but, when they are ſituated higher, they have the mean temperature of the atmoſphere, at the height of the place. There are variations, however, from this law, according to the depth of their ſources, the ſtrata through which they paſs, and the ſize of the hills from which they flow.

PROP. LXIV.

In the bowels of the earth there is a permanent heat, which is different from that of the air, of the waters, and of ſmall bodies on the ſurface of the earth; it being commonly about 50°, when there are no pyritical ſtrata, or other foſſils which generate heat.

Cor. 1. The water below ice is often conſiderably warmer than the ice. The cold of the upper ſurface of ſnow lying upon the ground, is ſometimes, 0, while the cold of the under ſurface is a little below 32°. Some lakes do not freeze till the winter is far advanced, and ſome do not freeze at all.

Cor. 2. Hence, wild beaſts defend themſelves from the cold, by going into caverns; and, men, by covering themſelves with ſnow, or placing their tents over holes in the earth; and, hence, ſnow is a defence to vegetables, during ſevere froſt.

Cor. 3. Hence, the equal temperature that is in cellars; and, hence, the lower ſtorey in high houſes, is cooleſt in the forenoon, and the uppermoſt hotteſt, this temperature being reverſed at night; and, when the chimneys are open, and without fire, there is a current of air from the rooms to the atmoſphere, and the contrary, at night.

PROP. LXV.

The ocean, from the depth to which it reaches in the earth, its conſtant motion, its power of conducting fire, its tranſparency, and evaporation, is never frozen in temperate regions; and, from the laſt three of theſe cauſes, it is eaſily heated by the rays of the ſun. Accordingly, the heat of the current from the Gulph of Mexico, is about 82°, which it loſes at the rate of two degrees to every three degrees of latitude, till it is of the ſame temperature with the reſt of the ocean; and this ſo regularly, that a thermometer may be uſed, not only for correcting a ſhip's courſe, but for ſhewing her place in dangerous ſituations.

Cor. 1. Hence, the ſeaſons are very mild on ſea-coaſts, and in iſlands, compared to inland places of the ſame latitude; while places, however, not far from the ſea, are ſubject to greater, though ſhort, variations of heat and cold, by the ſudden changes on the latent heat of the air, produced by temporary vapours.

PROP. LXVI.

Though the medium annual heat of places on the ſurface of the earth, depends much upon their diſtance from the poles, and the obliquity of the ſun's rays; yet, it depends more upon the height of the place, its diſtance from the ſea, the ſerenity of the ſky, the length of the day, the nature of the ſoil, ſubterraneous fires, the denſity, and moiſture of the air, the winds, the neighbouring rivers, lakes, woods, hills, and regions covered with ſnow, or ice.

PROP. LXVII.

The ground, if not wet, is ſeldom frozen deeper than a few feet, even in northern countries.

At St. Peterſburgh, A. D. 1739, the air was 30° below 0; and A. D. 1759, 42°; at Selingenſkoy, it has often been 55°; at Keringens, A. D. 1738, it was 113°; at Jeniſſa, A. D. 1735, 120°; at Glaſgow, A. D. 1768, 2°; at Chatham, A. D. 1776, 35°; at Glaſgow, A. D. 1780, 14°; at St. Peterſburgh, A. D. 1780, 57°; in Sweden, A. D. 1782, 62°; and, in Hudſon's Bay, A. D. 1786, 50°, or about 10° below the freezing of quickſilver.

PROP. LXVIII.

When there are no clouds, the ground is much heated by the ſun's rays; and more or leſs, according to its nature, and ſituation. In many parts of Europe, it has been heated to 150°; and, in ſome of the inland parts of Africa, it is ſaid, to 212°.

The air at St. Peterſburgh, A. D. 1734, was 98°; at Leyden, A. D. 1750, 92°; at Utrecht, A. D. 1733, 94°; at London, A. D. 1746, 85°; and the ſame in Perthſhire; at Senegal, it is often 110°; and at Podor, 134°. In large towns, and in hilly countries, it is often increaſed, far above that of the medium heat of the latitude, by the warmth of towns, by its confinement, and by the reflection of the ſun's rays.

PROP. LXIX.

Streams of water that iſſue from the earth, near pyritical ſtrata, have various degrees of heat from the mean temperature of the place to 200°; near volcanos, they iſſue with the heat of boiling water; and, when there is not a ſufficient aperture, ſteam, and tremours of the ground enſue.

The moſt apyrous foſſils are melted by volcanos, and thrown out in great floods.

DIVIS. 19.

OF THE HEAT OF THE SUN AND PLANETS.

PROP. LXX.

As heat depends upon other circumſtances much more than upon the immediate rays of the ſun; and, as the nature of the matter of the ſun and planets is unknown, we can form no judgment of their heat; nor is the heat of the planets to be eſtimated by their diſtance from the ſun.

DIVIS. 20.

THEORIES OF FIRE.

Of the moſt celebrated theories concerning fire; and a theory of it founded upon the above, and other experiments.

SECT. XIII.

COROLLARIES TO THE ABOVE SECTIONS.

PROP. I.

The combination, and decompoſition of bodies, by ſolution, precipitation, evaporation, diſtillation, fermentation, putrefaction, and fuſion are effected by the principles above eſtabliſhed.

PROP. II.

Painting, dyeing, cementing, ſoldering, etching, depend upon the ſame principles; and, the art of manufacturing metals, glaſs, artificial gems, paſtes, and earthen ware.

Of vegetation, and the riſe of ſap in vegetables. Of the animal economy; and the ſecretions in animal bodies.

PROP. III.

Several fluids may be mixed together, and yet may be drawn off unmixed, by filters, and capillary ſyphons.

Of the ancient method of ſplitting rocks, and of mining, by fires, cold water, and wedges.

PROP. IV.

If dried pins of wood, are driven into bores, or crevices of rocks, and moiſtened with water, they will ſometimes ſwell with ſuch force as to ſplit the rocks.

PROP. V.

One hundred pounds of Britiſh gun powder contains 75 lbs. of nitre, 15 lbs. of charcoal, and 10 lbs. of ſulphur; but, theſe proportions are not the ſame in every country, and for every purpoſe.

PROP. VI.

The quantity of air obtained by firing gun powder, is equal in bulk to 244 times the bulk of the powder fired, when the air ſo produced, is compreſſed by the atmoſphere, and reduced to the ſame heat.

Cor. 1. If the elaſtic power of common air is increaſed four times, by a heat equal to that of iron, juſt beginning to grow white; and, if the air from gun powder is equally affected by heat, then its expanſive force, in the inſtant of exploſion, is about a thouſand times greater than the preſſure of the atmoſphere.

Cor. 2. Hence the effect of firing gun powder, in cannon, mortars, and bombs; and, the advantage of uſing it in ſplitting rocks, in quarries, and mines.

PROP. VII.

Rockets may be raiſed to the height of 1500 feet by the burning of the gun powder in them; and fire-works of many different kinds, may be made.

Of the various improvements that have been made upon gun powder; and the beſt method of preſerving and applying it to uſe.

PROP. VIII.

Six pounds of pulvis fulminans are made of 3 lbs. of nitre, 2 lbs. of an alkaline ſalt, and 1 lb. of ſulphur. A precipitate of gold from aqua regia by a fixed alkali, is aurum fulminans. Though theſe bodies make a great exploſion, they are uſeleſs in mining, and in war. The firſt, becauſe it muſt be gradually heated; and, the ſecond, becauſe of its price, and its being eaſily fired by rubbing.

PROP. IX.

One ounce of water makes 9250 cubic inches of ſteam, of equal elaſtic force with the ſame number of inches of common air; the weight of the ſteam being one-fifth part of the weight of the air, and the ſteam of one cubic inch of water being ſufficient to exclude the air out of a veſſel of 4000 inches in capacity.

Cor. 1. Hence, the great effect of ſteam in working pumps, mills, and machines of various ſorts, which require a great power, that is eaſily generated, and ſuddenly deſtroyed.

Cor. 2. Hence, the effects of ſteam in Papin's digeſter; and, the great heat, and repulſive power, which it acquires in that machine.

Cor. 3. The ſteam generated in the bowels of the earth, is a power that is able to make the great convulſions, called earthquakes; and, their exiſtence muſt be irregular, and temporary, according as the ſteam gets vent, or is deſtroyed by cold water.

PROP. X.

Hempen ropes, by the application of water, or by the moiſture of the air, twiſt, and ſhorten.

Cor. 1. Hence, the effect of moiſture upon cords, canvas, and the ropes of pullies.

Cor. 2. Ropes may be uſed inſtead of pumps, or buckets, for raiſing water out of wells.

PROP. XI.

Configurations are diverſified in their forms, without end; according to the ſtrength of the menſtruum, the body diſſolved, the time of evaporation, and the temperature of the place; but, in the ſame circumſtances, they are always the ſame.

PROP. XII.

The common cryſtals of ſea ſalt are cubes, many of which are pyramids, with a hollow quadrangugular baſe; of nitre, parallelopipeds with ſix angles; of ſalt of laurel, partly hexangular parallelopipeds, and partly truncated pyramids; of ſalt of liquorice, double hexangular pyramids; of ſalt of white hellebore, rhombuſes; of vitriol, rhomboidals; of alum, octogonals; of lead, cubes; of tin, quadrangular pyramids; of copper, oblique angled parallelopipeds; of iron, rhomboidals; and, of other bodies, other ſolids; the cryſtals of the ſame body being invariably the ſame, when formed in the ſame circumſtances.

Of the figures that are on marbles, ſlates, flints, agates, mocha ſtones, when taken out of the earth; and, the method of making ſuch figures by art.

Of the chemical vegetation of metals, and reſuſcitation of plants.

Of the forms of precious ſtones, and columnar rocks; with the theories concerning the manner in which they ſeem to have been formed in the earth.

Of the aſcent of vapour, or riſe of water, in the atmoſphere.

PROP. XIII.

There is an evaporation of water, not only in the open air, as in Sect. XII. Divis II. but in an air pump vacuum; and, the vapour produced is about one thouſand and eight hundred times lighter than common air. There is likewiſe an evaporation of water when the air is below 32°.

Of vapours, clouds, dew, rain, hoar-froſt, ſleet, ſnow, hail, and the configurations of water by cold.

PROP. XIV.

Fogs are produced by two cauſes; the precipitation of very ſmall particles of water from moiſt air; or, the abſorption of very ſmall particles of water by dry air.

Cor. Hence their effects are very different upon ſtones, plaſter, wood; and, upon living vegetable, and animal bodies.

SECT. XIV.

THEORIES IN SOMATIOLOGY.

Of the immediate cauſe of the above facts; or, the theory of corpuſcular attraction, elective attraction, coheſion, repulſion, and, the phenomena of fire; from which it appears, that the minute parts of matter are conſtantly governed by accurate laws, and wiſe deſign.

MINERALOGY

Comprehends Foſſils, or bodies taken out of the earth; and, they are either ſuch as have not organized parts, are not produced by ſeeds, and give no marks of ſenſation; or, ſuch as belong to the vegetable, and animal kingdoms, but are changed in their appearances, and properties, by lying in the earth.

SECT. I.

A SYSTEM OF FOSSILS.

CLASS I.

EARTHY FOSSILS.

ORDER I. SIMPLE EARTH.

Genus. 1. PONDEROSA EARTH.

Species.

1. Terra Auvergna.
2. Calx Aquatica.

ORDER II. COMPOUND EARTHS.

DIVIS. I. CALCAREOUS BODIES.

Genus 1. SPATHUM.

Species.

1. Spathum Pellucidum.
2. Spathum Opacum.
3. Stalactites.
4. Tophi.
5. Agaricon Minerale.
6. Creta Communis.
7. Creta Fluida.
8. Creta Silicea.

Genus 2. GYPSUM.

Species.
1. Gypſum Fibroſum.
2. Alabaſtrum.

Species
3. Alabaſtr. Fibros.
4. Lap. Specularis.

Genus 3: LAPIS CALCARIUS.

Species.
1. Calx Alba.
2. Calx Nigra.
3. Calx Griſea.
4. Calx Mixta.
5. Hammites.
6. Lap. Portlandicus.
7. Schiſtos.

Species.
8. Marmor Album.
9. Marmor Griſeum.
10. Marmor Coeruleum.
11. Marmor Viride.
12. Marmor Rubrum.
13. Marmor Nigrum.
14. Marmor Mixtum.

Genus 4. TUNGSTEN.

Species.
1. Lap. Ponder. Albus.

Species.
2. Lap. Pond. Griſeus.

Genus. 5. FLUOR.

Species.
1. Spathum Pellucidum.
2. Spathum Album.
3. Spathum Flavum.
4. Spathum Coeruleum.
5. Spathum Viride.

Species.
6. Spathum Rubrum.
7. Spathum Violaceum.
8. Spathum Fuſcum.
9. Spathum Mixtum.

Genus. 6. CREUTZEN.

Species.
1. Creutzen Fuſcus.

Species.
2. Creutzen Flavus.

Genus 7. TRAVERTINO.

Species.
1. Lapis Fongaia.
2. Fongaia Griſea.

Species.
3. Fongaia Coerula.
4. Fongaia Flava.

Genus. 8. MARGA.

Species.
1. Marga Barytica.
2. Marga Magneſia.

Species.
3. Marga Argillacea.
4. Marga Silicea.

Genus 9. GRITCALCAR.

Species.
1. Sternſpathum.

Species.
2. Moelonum.

Genus 10. LAPIS SUILLUS.

Species.
1. Lap. Suil. Griſeus.
2. Lap. Suil. Fuſcus.

Species.
3. Lap. Suil. Nitens.
4. Lap. Suil. Granularis

Genus 11. PYRITCALCAR.

Species.
1. Lap. de S. Ambroix.

Species.
2. Idem Griſeus.

Genus 12. FERCALCAR.

Species.
1. Fercalcar Flavum.

Species.
2. Fercalcar Rubrum.

Genus 13. CALPONDEROS.

Species.
1. Calponderos Albus.

Species.
2. Calponderos Flavus.

Genus 14. CALMURIAT.

Species.
1. Lap. Mur. Compact.

Species.
2. Lap. Mur. Pulverulentus.

Genus 15. CALARGIL.

Species.
1. Marga Griſea.
2. Marga Flava.

Species.
3. Marga Rubra.
4. Marga Fuſca.

Genus 16. CALSILEX.

Species.
1. Spathum Stellatum.

Species.
2. Lap. S. Helenae.

Genus 17. CALPORPHYRIT.

Species.
1. Calx Feltſpathea.

Species.
2. Calx Shoerla.

The characters of the claſſes, orders, diviſions, ſubdiviſions, and of ſome of the genera, of foſſils, are given in Somatiology. The characters of the other genera, are given here, at the end of the diviſions, when thought neceſſary. The ſpecies differ from their genera, only in the proportions of their component parts, hardneſs, colour, or form. The ſynonymous, and vulgar, names are marked upon the boxes, in which the ſpecimens are contained.

Though the five genera of the ſimple earths are procured from foſſils, yet, the terra ponderoſa is the only one that has certainly been found in ſuch a ſtate, as to be got pure without the application of fire, or acids. There are only two ſpecies of it, but the ſecond has ſome varieties.

Some of theſe genera, which have the ſame bodies marked on the right and left hand ſides as their component parts, are different on account of the proportions of theſe parts, or, of a third body which cements them.

The firſt five of the calcareous genera are diſtinguiſhed by their tranſparency, texture, or form. There is no diſtinction between ſome of the ſpecies, ſuch as limeſtone and marble, but the poliſh which they take, or the uſes to which they are put.

DIVIS. II. PONDEROSA BODIES.

Genus 1. BAROSELENITES.

Species.
1. Lap. Baryt. Aeratus.
2. Spathum Ponderoſum.

Species.
3. Spathum Bindheimi.

Genus 2. LAPIS BONONIENSIS.

Species.
1. Selenites Albus.

Species.
2. Selenites Ruber.

Genus 3. PONACIDSPAT.

Species.
1. Baryt. Fluor.

Incertum.

Genus 4. PONTUNGSPAT.

Species.
1. Fluor Tungſteni.

Incertum.

Genus 5. PONSILFER.

Species.
1. Ponſilfer Siliceum.

Species.
2. Ponſilfer Ferreum.

Genus 6. LAPIS HEPATICUS.

Species.
1. Hepaticus Albus.
2. Hepaticus Griſeus.
3. Hepaticus Flavus.

Species.
4. Hepaticus Fuſcus.
5. Hepaticus Niger.

The firſt genus is ſtriated; its Specific Gravity is 4,331; and, it has the appearance of alum.

The ſecond genus, and its ſpecies, have many different names; their varieties are white, grey, yellow, red; ſome of them are not harder than chalk; but, in general, they are compact, though not ſo hard as to give fire with ſteel; ſome of them have a fibrous form, and are polygons, with different degrees of tranſparency; they do not burn to Paris Plaſter like gypſum, nor are fuſible per ſe, with a blow-pipe.

It is doubtful whether the third, fourth, and fifth genera are found in the earth, though they are eaſily formed by art.

The texture of the laſt genus is laminal and ſcalely; it takes a poliſh like alabaſter; and, when rubbed, gives a ſmell like hepar ſulphuris.

DIVIS. III. MAGNESIA BODIES.

Genus 1. KEFFEKILL.

Species.
1. Keffekill Albus.
2. Keffekill Flavus.

Genus 2. STEATITES.

Species.
1. Steat. Thionville.
2. Steatites Sileſiae.
3. Steatites Viridis.
4. Lapis Ollaris.

Genus 3. ASBESTOS.

Species.
1. Aſbeſtos Plumoſus.
2. Aluta Montana.

Genus 4. AMIANTHUS.

Species.
1. Amianthus Fragilis.
2. Amianthus Flexilis.

Genus 5. LAPIS SERPENTINUS.

Species.
1. Serpentinus Albus.
2. Serpentinus Viridis.
3. Serpentinus Fuſcus.
4. Serpent. Rubeſcens.
5. Serpentinus Flavus.
6. Serpentinus Coerulus.
7. Serpentinus Niger.
8. Serpent. Maculatus.
9. Serpentinus Venoſus.

Genus 6. TALCUM.

Species.
1. Talcum Venetium.
2. Talcum Muſcovitum.

Genus 7. MAGACIDSPAT.

Species. Incertum.

Genus 8. MAGACIDTUNG.

Species. Incertum.

Genus 9. MAGMIXTAE.

Species.
1. Creta de Briançon.
Species.
2. Creta Brian. Rubra.

Genus 10. MAGCALCAR.

Species.
1. Potzevera
2. Nero di Prato.
Species.
3. Verde di Suza.
4. Lap. Nephrit. Gyps.

Genus 11. MAGPONDEROS.

Species.
1. Gabro Maculata.
Species.
2. Gabro Venoſa.

Genus 12. MALARGIL.

Species.
1. Steatites Argillacea.
Species.
2. Steatites Bituminoſa.

Genus 13. MAGSILEX.

Species.
1. Feltſpath. Serpentin.
Species.
2. Shoerl Serpentinum.

The firſt ſpecies of the third genus is of a greeniſh colour, and conſiſts of parallel filaments; it does not ſtrike fire with ſteel, nor efferveſce with acids; when heated, it becomes whitiſh, and, when pure, is not fuſible per ſe, by a blow-pipe; it differs externally from ſome of the ſhoerls only by the want of tranſparency, and the unevenneſs of its fractures; ſome of the varieties of it contain, in 100 ounces, 62 of ſiliceous, 13,7 of magneſia, 12 of calcareous, and 1,7 of argillaceous earth, together with 10,6 of iron. The ſecond ſpecies reſembles leather; and, like it, floats upon water.

The fourth genus is like the firſt ſpecies of the laſt genus, but its fibres are ſo flexile that they may be woven into cloath; and, the proportions of its component parts are different.

Scales, which are almoſt tranſparent, diſtinguiſh the firſt ſpecies of the ſixth genus; and, the ſecond, conſiſts of elaſtic tranſparent leaves, ſeveral inches in length and breadth.

DIVIS. IV. ARGILLACEOUS BODIES.

Genus 1. AGARICON MINERALE.

Species.
1. Agaricon Calcarium.

Species.
2. Agaricon Martiale.

Genus. 2. ARGILLA.

Species.
1. Creta Communis.
2. Argilla Fuſibilis.
3. Argilla Apyra.

Species.
4. Lithomarga.
5. Argilla Fullonis.
6. Terra Lemnia.

7. Terra Colognenſis.
8. Terra Porcelanica.
9. Argilla Laterum.
10. Creta Rubra.
11. Creta Coerula.
12. Terra Umber.
13. Argilla Viridis.
14. Argilla Nigra.
15. Argilla Saxonica.

Genus 3. EMBRYAL.

Species.
1. Argilla Micacea.

Species.
2. Argilla Squamoſa.

Genus 4. EMBMARAL.

Species.
1. Arg. Mur. Mollis.

Species
2. Arg. Mur. Dura.

Genus 5. MICA.

Species.
1. Mica Pura.
2. Mica Alba.
3. Mica Rubra.
4. Mica Flava.

Species.
5. Mica Viridis.
6. Mica Fuſca.
7. Mica Niger.

Genus. 6. SHISTUS TEGULARIS.

Species.
1. Shiſtus Coerulus.
2. Shiſtus Griſeus.
3. Shiſtus Albens.

Species.
4. Shiſtus Rubeſcens.
5. Shiſtus Scriptorius.

Genus 7. SHISTUS PYRITICUS.

Species.
1. Shiſt. Pyrit. Griſeus.
2. Shiſt. Pyrit. Fuſcus.

Species.
3. Shiſt Pyrit. Viridis.
4. Shiſt. Pyrit. Niger.

Genus 8. SHISTUS BITUMINOSUS.

Species.
1. Shiſt. Bit. Laminos.

Species.
2. Shiſt. Bit. Compactus.

Genus 9. GRITARGIL.

Species.
1. Gritargil Laminoſa.
2. Gritar. Lam. Griſea.
3. Gritar. Lam. Flava.
4. Gritar. Lam. Rubes.
5. Gritar. Compacta.

Species.
6. Gritar. Compac. Alba.
7. Gritar. Compac. Rubes.
8. Gritar. Compac. Fuſca.
9. Gritar. Compac. Martial.

Genus. 10. HORNSTEN.

Species.
1. Hornſten Striatus.
2. Hornſten Niger.

Species.
3. Hornſten Griſeus.
4. Lapis Killas.

Genus 11. LAPIS BUFONIS

Species.
1. Lap. Buf. Cellular.

Species.
2. Lap. Buf. Spathoſus

Genus 12. ZEOLITES.

Species.
1. Zeolites Pellucidus.
2. Zeolites Albus.
3. Zeolites Flavus.

Species.
4. Zeolites Viridis.
5. Zeolites Ruber.

Genus 13. CRETA RUBRA.

Species.
1. Creta Rub. Vivida.

Species.
2. Creta Rubra Fuſca.

Genus 14. ARGILMIXTAE.

Species.
1. Marga Micacea.
2. Shiſtus Micaceus.
3. Gritargil. Micacea.

Species.
4. Gronſten.
5. Shiſtargilgrit.
6. Shiſthornſten.

Genus 15. ARGILCALCAR.

Species.
1. Marm. Nero Antico.

Species.
2. Idem Maculatum.

Genus. 16. ARGILPONDEROS.

Species.
1. Argilbarytica.

Incertum.

Genus 17. ARGILMURIAT.

Species.
1. Shisſteatites.
2. Shiſtſerpentinus.

Species.
3. Michornſten.
4. Schneideſten.

Genus. 18. ARGILSILEX.

Species.
1. Stelleſten.
2. Saxum Novaculum.
3. Gronſten Viridis.

Species.
4. Binda.
5. Lapis Growan.
6. Micafeltſpar.

Genus. 19. ARGILMICA.

Species.
1. Porphyrites Micaceus.

Species.
2. Hornſten Spathoſus.

The firſt ſpecies of the firſt genus is white like ſnow. The ſecond ſpecies is greyiſh, from a mixture of iron, and clay.

Beſides argillaceous and ſiliceous earths, the ſecond ſpecies of the ſecond genus, contains a mixture of calcareous, or muriatic earths, or gypſum, fluor, feltſpar, or iron; and, it is more or leſs fuſible, according to the proportions of theſe bodies. The third ſpecies conſiſts of argillaceous, and ſiliceous earths, without any mixture of metallic bodies, or in a very ſmall proportion. The fifth, is of different colours, is ſmooth to the touch, and ſometimes froths in water; the readineſs with which it abſorbs oil, the fineneſs of its particles, which do not hurt cloth, and its being very diffuſive in water, which makes it eaſily waſhed out, are properties that give it great value to fullers. The ſixth ſpecies is a yellowiſh clay of the ſame ſort. The ſeventh, is any white clay that retains its colour in the fire; and, pipeclay is its common name. The eighth, differs from the former in the quantity and extreme fineneſs of its ſiliceous particles; it contains no oily matter, and, therefore, retains its colour in the greateſt heat. The ninth, is brick clay, which conſiſts of various bodies; the beſt containing iron, and a large proportion of ſiliceous ſand. The tenth, is a mixture of common clay with the calx of iron. The eleventh, contains a mixture of pyrites and vitriolic acid. There are two varieties of the twelfth ſpecies; the one conſiſts of particles of wood mixed with bitumen; and, the other is a mixture of bitumen, clay, and iron. The thirteenth ſpecies is common clay mixed with copper, and cobalt. There are two varieties of the fourteenth; the one conſiſts of common clay, and pyrites; the other of common clay, and bitumen. The laſt ſpecies is of a purple colour, with white, yellow, or red veins; and, is compoſed of clay, bitumen, and metallic bodies.

The firſt ſpecies of the fifth genus is pellucid; and the other ſpecies have mixtures of iron, and of ſome metallic bodies, which give them various colours. The white and yellow ſort have a glittering metallic appearance; they are ſmooth, but not greaſy to the touch, which diſtinguiſhes them from talc.

Freeſtone is the common name of the ninth genus, becauſe it is eaſily cut, and in all directions. The nature of its cementing matter, and the metallic and ſaline bodies with which it is mixed, affect the beauty and duration of ſome of its ſpecies when expoſed to the weather.

The ſix laſt genera are compounds of various bodies, in various proportions, and with names and appearances that are often deluſive.

DIVIS. V. SILICEOUS BODIES.

Genus I. QUARTZUM CRYSTALLUM.

Species.
1. Cryſtal. Pellucidum.
2. Cryſtal. Flavum.
3. Cryſtal. Viride.
4. Cryſtal. Violaceum.
5. Cryſtal. Coerulum.

Species.
6. Quartzum Commune.
7. Quartzum Nigrum.
8. Quartzum Rubrum.
9. Quartzum Coerulum.

Genus 2. SILEX.

Species.
1. Silex Flavus.
2. Silex Niger.
3. Silex Variegatus.

Species.
4. Silex Sardus.
5. Stigmites.
6. Haemachates.

Genus 3. PETROSILEX.

Species.
1. Chert Communis.
2. Chert Coerulus.

Species.
3. Chert Griſeus.
4. Chert Flavus.

Genus 4. JASPER.

Species.
1. Jaſpis Rubra. 9.
2. Jaſpis Viridis. 11.
3. Jaſpis Coerula. 9.
4. Jaſpis Griſea. 9.

Species.
5. Jaſpis Alba. 9.
6. Jaſpis Variegata. 9.
7. Sinople. 9.

Genus 5. ACHATES.

Species.
1. Achates Orientalis. 12.
2. Achates Occidentalis.
3. Opalus. 10.
4. Pſeudopalus.
5. Calcedonius. 11.
6. Chacholonius.

Species.
7. Onyx Communis. 12.
8. Onyx Laminoſus.
9. Carneolus Ruber. 11.
10. Carneolus Flavus. 7.
11. Carneolus Albus. 6.
12. Sardonyx. 12.

Genus 6. GEMMAE.

Species.
1. Adamas Ormos. * 20.

Species.
2. Adamas Flavus. 19.

Species.
3. Adamas Rubes. 19.
4. Adamas Virid. 19.
5. Adamas Coer. 19.
6. Adamas Cubic. 18.
7. Cryſtal. Pelluc.* 11.
8. Rubinus Orient. 17.
9. Rubin. Braſilens. 16.
10. Rubin. Albeſc. 13.
11. Topazius. 15.
12. Hyacinthus. 12.

Species.
13. Smaragdus. 12.
14. Emeraldus. 12.
15. Cryſolithus. 10.
16. Beryllus. 11.
17. Sapphir. Coerulus. 16.
18. Sapphir. Albeſc. 17.
19. Sapphir. Rubeſc. 17.
20. Amethyſtus. 11.
21. Granat. Gemma.* 12.

Genus 7. CHRYSOPRASIUM.

Species.
1. Chryſop. Commune.

Species.
2. Chryſopras. Albeſcens.

Genus 8. LAPIS LAZULI.

Species.
1. Lap. Laz. Coerulus.
2. Lap. Laz. Uniformis.

Species.
3. Lap. Laz. Pyritaceus.

Genus 9. LAPIS AMAZONUM.

Species.
1. Lap. Amaz. Albus.
2. Lap. Amaz. Griſeus.

Species.
3. Lap. Amaz. Viridis.
4. Lap. Amaz. Flaveſc.

Genus 10. PETUNSE.

Species.
1. Spathum Durum.
2. Petunſe Ruber.
3. Petunſe Flavus.

Species.
4. Petunſe Fuſcus.
5. Petunſe Viridis.
6. Petunſe Violaceus.

Genus 11. PETROGARNET.

Species.
1. Petrogar. Opacus.
2. Petrogar. Pellucidus.

Species.
3. Garnatus Obſcurus.
4. Garnatus Vividus.

Genus 12. SHOERL.

Species.
1. Shoerl Pellucidus. 10.

Species.
2. Shoerl Opacus. 10.

Genus 13. BARSHOERL.

Species.
1. Barſhoerl Fuſcus.

Species.
2. Barſhoerl Albeſcens.

Genus 14. TOURMALIN.

Species.
1. Tourm. Ceylon. 10.
2. Tourm. Braſilenſis. 9.

Species.
3. Tourm. Tyrolenſis. 10.

Genus 15. BASALTES.

Species.
1. Baſaltes Griſeus.
2. Baſaltes Niger.

Species.
3. Trapp Suedorum.

Genus 16. SILARFER.

Species.
1. Silarfer Fuſcus.

Species.
2. Silarfer Griſeus.

Genus 17. LAPIS MONNETI.

Species.
1. Spat. Mart. Griſeum.

Species.
2. Spat. Martiale Fuſcum.

Genus 18. COS TURCICA.

Species.
1. Cos Tur. Mollis.

Species.
2. Cos Tur. Dura.

Genus 19. COS GRANOSA.

Species.
1. Cos Granoſa Griſea.

Species.
2. Cos Granoſa Flava.

Genus 20. GRITSILEX.

Species.
1. Saxum Margariticum.
2. Saxum Keredgeum.

Species.
3. Shiſtus Coticularis.
4. Lapis Percolarius.

Genus 21. SILMIXTAE.

Species.
1. Silmixtae Flaveſc.

Species.
2. Silmixtae Rubeſcen.

Genus 22. SILCALCAR.

Species.
1. Silcalcar Quartzum.
2. Silcalcar Graniticum.

Species.
3. Silcalcar Alpinum.
4. Silcalcar Jadenſe.

Genus 23. SILPONDEROS.

Species.
1. Baryt. Comp. Alba.

Species.
1. Baryt. Comp. Griſea.

Genus 24. SILMURIAT.

Species.
1. Silmuriat Shoerl.
2. Silmuriat Quartzum.

Species.
3. Silmuriat Fuſcum.
4. Silmuriat Granoſum.

Genus 25. SILARGIL.

Species.
1. Granitello.
2. Granitone.
3. Lap. Penmaurenſis.
4. Granatus Rubeſcens.
5. Granatus Griſeus.

Species.
6. Granatus Viridis.
7. Granatus Variegatus.
8. Whinſaxum Griſeum.
9. Whinſaxum Fuſcum.
10. Porphyrus.

Genus 26. SILMANDEL.

Species.
1. Amygdaloides.
2. Amyg. Serpentinus.
3. Amyg. Micaceus.

Species.
4. Variolites.
5. Variolit. Quart.
6. Angermannicum.

Many authors give the name of the firſt ſpecies of the firſt genus to the whole of this diviſion. The firſt ſpecies is amorphous, or in the form of polygons, or of pyramids. The ſixth, is found either in a cryſtallized ſtate, or amorphous. Both of them are tinged with different colours by the metallic particles with which they are mixed; and crack when heated.

The fifth genus is the agate, or pebble, of the moderns. The ſpecies and varieties of it are many. Some are almoſt tranſparent, ſome have various colours, ſome veins of quartz, or jaſper, and, ſome the figures of plants.

Under the ſixth genus, the ſpecies have been various in different ages. Some of the ſpecies of the fifth were anciently reckoned among them, and, an almoſt incredible value was ſet upon them. Of the above ſpecies, the firſt is the hardeſt of all bodies, and exceeds every gem in brilliancy. The ſeventh, reſembles diamonds in tranſparency; but is ſoft, and is injured by heat. The eighth, has a bright red colour. The ninth, is paler. The tenth, is almoſt brown. The eleventh, is of a golden colour; and its form, a cube, a parallelopiped, or a priſm. The twelfth, is a bright yellow, and has a priſmatic form. The thirteenth, is a bright green, tinged with yellow. The fourteenth, is a deep green, tinged with blue. The fifteenth, is a light yellowiſh green. The ſixteenth, is a fine ſea green. The ſeventeenth, eighteenth, and nineteenth have a ſky blue colour, with different ſhades. The twentieth, is a pale bluiſh red; it is found in hexangular priſms; and there are many varieties of it. The twenty-firſt, is of a red colour, with many ſhades, and is found both cryſtallized, and amorphous.

Different proportions of phlogiſton, and iron, in the compoſition of precious ſtones, give them different colours, and varieties. Their relative hardneſs is expreſſed in proportional numbers, by the figures which are added to their names. The ſpecific gravity of the diamond is 3,4, of the ruby 4,2; and, of the reſt of the precious ſtones, from 4,2 to 2,1.

The ſeventh genus is ſemitranſparent, and of an apple green colour; it is harder than green fluors; and is not found cryſtallized.

Petunſe, or china-ſtone, is of many different colours, amorphous, and cryſtallized; 100 parts of it contain about 67 of ſiliceous earth, 14 of argillaçeous, 11 of ponderoſa, and 8 of magneſia.

The eleventh genus, or granatus gemma, is found both amorphous and cryſtallized; 100 grains of it contain about 49 of ſiliceous earth, 30 of argillaceous, 11 of calcareous, and 10 of iron.

One hundred parts of the fifteenth genus contain 52 of ſiliceous earth, 15 of argillaceous, 8 of calcareous, 2 of magneſia, and 25 of iron. It has a ferruginous hue; and, from its texture, was uſed as a touchſtone for the precious metals.

The twenty-firſt genus is a compound of ſiliceous earth, with ſiliceous bodies, in various proportions.

Stellſten of the Swedes makes the firſt ſpecies of the twenty-fifth genus. The ſecond is the Findland rapakivi, which, ſometimes, contains ſaltpetre, and, ſometimes, common ſalt. The third, is a compound of quartz and hornſten, and is found in the Britiſh mountains. The other ſpecies are well known by theſe, or local names. The fourth, fifth, ſixth, and ſeventh, were made into ornaments, and ſtatues by the ancients, though, at firſt ſight, they appear very unfit for that purpoſe. They are commonly found in maſſes that are detached, and amorphous. The eighth and ninth ſpecies are found in ſtrata; are uniform in their texture, and appearance; and have ſeveral varieties. Their great hardneſs, their being unaffected by the weather, and by moſt other bodies, make them fit for paving, and ſeveral uſeful purpoſes. The laſt ſpecies comprehends ſiliceous ſtones which contain feltſpar, quartz, ſhoerl, mica, chert, or ſerpentine.

The ſpecies of the laſt genus are compounds of quartz, mica, ſerpentine, ſteatites, ſhoerl, or jaſper.

ORDER III. EARTHY LAVAS.

Genus 1. LAVA CELLULARIA.

Species.
1. Lava Nigra.
2. Lava Griſea.
3. Lava Fuſca.

Species.
4. Lava Rubra.
5. Lava Flava.
6. Lap. Molaris Rhenor.

Genus 2. LAVA COMPACTA.

Species.
1. Lava Compac. Nigra.

Species.
2. Lava Compac. Fuſca.

Genus 3. LAVA VITREA.

Species.
1. Lava Vit. Nigra.
2. Lava Vit. Coerula.

Species.
3. Lava Vit. Viridis.
4. Lava Vit. Variegata.

Genus 4. SEMILAVA.

Species.
1. Semilava Nigra.
2. Semilava Griſea.
3. Semilava Breccia.
4. Terra Pouzzolana.
5. Terra Traaſs.

Species.
6. Arena Tripolitana.
7. Pumex Albus.
8. Pumex Griſeus.
9. Pumex Fibroſus.

There are ſmall cavities in the ſpecies of the firſt genus, ſome of which are empty, and ſome are filled with vitrified matter. They, commonly, contain about 50 per cent. of ſiliceous earth, 25 of argillaceous, 5 of calcareous, and 20 of iron. Perhaps the lapis bufonis belongs to this genus.

The proportions of the component parts of the ſecond genus are nearly the ſame with that of the firſt. If there are no cracks in them, they give a ſound, when ſtruck.

A compleat vitrification makes the character of the third genus; the ſpecies of which have various colours. Their component parts are commonly the ſame with thoſe in the preceding genera, but in different proportions.

The three firſt ſpecies of the fourth genus conſiſt of bodies not thoroughly fuſed, which are united with compleat lavas. The fourth ſpecies conſiſts of half baked argillaceous particles, which, imbibing moiſture ſuddenly, dry the calcareous particles, and ſo form a cement under water. The fifth ſpecies, when pulveriſed, and mixed with quick-lime, makes a cement, in like manner. The ſixth, contains 90 per cent. of ſiliceous earth, 7 of argillaceous, and 3 of iron. The laſt three, have ſlender, parallel fibres, and are rough and porous; they ſwim in water, and ſeem to have been aſbeſtos decompoſed by fire, and mixed with ſmall proportions of calcareous, magneſia, and ſiliceous earths.

ORDER IV. EARTHY PETREFACTIONS.

Genus I. CALCAREA PETREFACTA.

LITHOPHYTA.

Species.	Species.
1. Coralia.	3. Milleporae.
2. Madreporae.	4. Tubulariae.

Species.
5. Aſtroitae.
6. Chymatitae.
7. Hippuriti.
8. Porpitae.

Species.
9. Corallo Fungitae.
10. Eſchara.
11. Cheratophyta.
12. Pyrites Coralloides.

TESTACEA.

Species.
1. Patelliti.
2. Planiti.
3. Canaliti.
4. Nautiliti.
5. Cochliti.
6. Nerititi.
7. Trochiliti.
8. Bucciniti.
9. Strombiti.
10. Turbiniti.
11. Volutiti.
12. Cylindriti.
13. Muriciti.
14. Purpuriti.
15. Globoſiti.
16. Porcellaniti.
17. Ammoniti.
18. Oſtraciti.

Species.
19. Chamiti.
20. Muſculiti.
21. Pinniti.
22. Telliniti.
23. Bucarditi.
24. Pectiniti.
25. Soleniti.
26. Gryphiti.
27. Anomiae.
28. Oſtreopectiniti.
29. Echiniti.
30. Lapides Judaici.
31. Aciculae Lapideae.
32. Acetabula Echinorum.
33. Vermiculiti.
34. Orthoceratiti.
35. Balaniti.

Genus 2. ARGILLACEA PETREFACTA.

Species.
1. Cochleotypolithi.
2. Buccinotypolithi.
3. Strombotypolithi.

Species.
4. Turbinotypolithi.
5. Ammonitotypolithi.
6. Oſtreotypolithi.

Species.
7 Chamotypolithi.
8. Muſculotypolithi.
9. Tellinotypolithi.
10. Pectinotypolithi.
11. Echinotypolithi.
12. Typolithi Lap. Jud.
13. Typolit. Acicul. Jud.
14. Orthoceratotypolit.
15. Cochlearum Nuclei.
16. Neritarum Nuclei.
17. Buccinorum Nuclei.
18. Stromborum Nuclei.

Species.
19. Turbinum Nuclei.
20. Globoſarum Nuclei.
21. Oſtrearum Nuclei.
22. Chamarum Nuclei.
23. Muſculorum Nuclei.
24. Bucardiorum Nuclei.
25. Pectinum Nuclei.
26. Diphyiti.
27. Hyſterolithi.
28. Echinorum Nuclei.
29. Alveoli.
30. Jacula Lapidea.

Genus 3. SILICEA PETREFACTA.

Species.
1. Phytolithi.
2. Lithoxylon.
3. Rizolithus.
4. Lithocalamus.
5. Lithophylla.
6. Carpolithi.

Species.
7. Phytotypol Plantar.
8. Phyt. Caulis Plantar.
9. Phyt. Fol. Arbor.
10. Phyt. Fruc. Plantar.
11. Lignum Terreum.
12. Radices Terreae.

Genus 4. LITHOMORPHI.

Species.
1. Uranomorphi.
2. Anthropomorphi.
3. Zoomorphi.
4. Phytomorphi.
5. Technomorphi.
6 Anthropoglyphi.
7. Zooglyphi.

Species.
8. Phytoglyphi.
9. Technoglyphi.
10. Lith. Mathematici.
11. Lapides Vaccini.
12. Aëtiti.
13. Lapides Sulcoſi.
14. Variolithi.

Species.	Species.
15. Olae Giganteae.	17. Ludi Corp. Vegetab.
16. Ludi Helmontii.	18. Ludi Corp. Animal.

The firſt twelve ſpecies of the firſt genus, are the habitations, or the works of inſects, found lying in the earth, and which it was formerly believed, were vegetating ſtones. The remaining ſpecies are the coverings, or parts, of animals, depoſited in the earth. They conſiſt of petrified ſhells, the prints of ſhells, mineralized ſhells, unchanged ſhells, or compounds of ſhells, and ſtones.

Similar petrefactions, and impreſſions on argillaceous bodies, conſtitute the ſecond genus.

The third genus conſiſts chiefly of petrified wood, or mineralized parts of vegetables.

Some of the ſpecies of all the three genera are ſo much compounded, that cuſtom may determine their place.

Luſus Naturae is the name that was given to the ſpecies of the fourth genus. It aroſe from a groſs ignorance of corpuſcular attraction, and, of the great variety of vegetable and animal bodies that are found in a foſſil ſtate.

ORDER V. MOULDS.

Genus I. HUMUS VEGETABILIS.

Species.	Species.
1. Humus Atra.	2. Humus Rubra.

Genus 2. HUMUS ANIMALIS.

Species.	Species.
1. Hum. Anim. Putres.	2. Hum. Anim. Terrea.

The ſurface of cultivated fields, and the ſurface of uncultivated fields upon which the leaves of trees have fallen for many ages, are covered with a blackiſh earth that makes the firſt ſpecies of the firſt genus; and, there is commonly found a reddiſh earth under theſe moulds which makes the ſecond ſpecies.

Animal bodies depoſited in the earth, and in a ſtate of putrefaction, make the firſt ſpecies of the ſecond genus; and, they make the ſecond, when they are fully decompoſed.

CLASS II.

SALINE FOSSILS.

ORDER I. SIMPLE SALTS.

DIVIS. I. ACIDS.

Genus 1. ACIDUM MEPHITICUM.

Species.	Species.
1. Ac. Mephit. Aerium.	2. Ac. Mephit. Combinat.

Genus 2. ACIDUM VITRIOLI.

Species.	Species.
1. Vit. Fluidis Combin.	2. Vit. Solidis Combin.

Genus 3. ACIDUM NITRI.

Species.	Species.
1. Ac. Nit. Fluidum.	2. Ac. Nit. Combinat.

Genus 4. ACIDUM MARINUM.

Species.	Species.
1. Ac. Mar. Alkalinum.	2. Ac. Mar. Terreum.

Genus 5. ACIDUM SPATHI.

Species.	Species.
1. Ac. Sp. Fluor. Combin.	2. Ac. Sp. Laz. Combin.

Genus 6. ACIDUM TUNGSTENI.

Species.	
1. Ac. Tungs. Calcar.	Incertum.

Genus 7. ACIDUM ARSENICI.

Species.	Species.
1. Ac. Ar. Plum. Combin.	2. Ac. Ar. Cobalt. Combin.

Genus 8. ACIDUM MOLYBDENAE.

Species.	
1. Ac. Molyb. Combin.	Incertum.

Genus 9. ACIDUM BORAÇIS.

Species.	
1. Ac. Bor. Combin.	Incertum.

Genus 10. ACIDUM SUCCINI.

Species.	
1. Ac. Suc. Combin.	Incertum.

Genus 11. ACIDUM PHOSPHORI.

Species.	Species.
1. Ac. Phos. Oſſeum.	2. Ac. Phos. Plumbeum.

The firſt ſpecies of the firſt genus is found in the form of air, in caverns, mines, and wells; and, the ſecond, is found combined with water, and with abſorbent earths.

Air and water, in caverns, and mines, are combined with the ſecond genus; but, it has not been found in the earth in a pure ſtate.

As the third genus is formed by the joint action of bodies which belong to all the kingdoms of nature, it may be placed in any of the three; but, it is commonly called a mineral acid, and its being found in the earth determines its place here. The firſt ſpecies of it is found floating in ſewers; and the ſecond, combined with argillaceous bodies, and with alkalis.

The fourth genus is found only when combined with alkalis, earths, and ſome metals.

None of the remaining genera are found in an uncombined ſtate; and, the bodies with which they are combined, are obvious from the names of the ſpecies.

DIVIS. II. ALKALIS.

Genus 1. ALKALI VEGETABILE FIXUM.

Species.
1. Alk. Veg. Fix. Aquea.

Species.
2. Alk. Veg. Fix. Alum.

Genus 2. ALKALI FOSSIL FIXUM.

Species.
1. Alk. Foſ. Acidulum.
2. Amphronitron.
3. Alkali Trona.

Species.
4. Alkali Kien.
5. Al. Foſ. Aquea.

Genus 3. ALKALI VOLATILE.

Species.
1. Al. Vol. Aquea.

Species.
2. Al. Vol. Argillacea.

The firſt ſpecies of the firſt genus is found in the wells of towns; and, the ſecond, is mixed with argillaceous bodies upon the ſurface of the earth; both, perhaps, being produced by the putrefaction of vegetables.

With the aerial, the vitriolic, and the marine acids, the foſſil alkali is often combined, and then it makes the firſt ſpecies of the ſecond genus. The ſecond, adheres to the walls of houſes. The third and fourth, are found mixed with argillaceous bodies, or efferveſcing upon their ſurface; and, the laſt, in mineral waters.

The firſt ſpecies of the third genus is found in ſome mineral waters; and, the laſt, in ſome moulds, marls, and clays.

ORDER II. COMPOUND SALTS.

DIVIS. I. NEUTRAL SALTS.

Genus 1. TARTARUM VITRIOLI.

Species.
1. Tar. Vit. Humoſum.

Species.
2. Tar. Vit. Argillaceum.

Genus 2. SAL GLAUBERI.

Species.
1. S. Gl. Aqua Combin.
2. S. Gl. Terra Combin.

Species.
3. S. Gl. Humo Combin.

Genus 3. AMMONIACUM VITRIOLATUM.

Species.
1. Am. Vit. Aq. Combin. Incertum.

Genus 4. NITRUM COMMUNE.

Species.
1. Nit. Nativ. Petroſum.
2. Nit. Nativ. Argillac.

Species.
3. Nit. Nativ. Fontanum.
4. Nit. Nativ. Parietum.

Genus 5. NITRUM CUBICUM.

Species.
1. Nit. Cub. Argillac. Incertum.

Genus 6. NITRUM AMMONIACUM.

Species.
1. Nit. Am. Aq. Combin. Incertum.

Genus 7. SAL DIGEST. SILVII.

Species.
1. Sal Silv. Aq. Combin.

Species.
2. Sal Silv. Humo Combin.

Genus 8. SAL COMMUNE.

Species.
1. Sal Com. Oceani.
2. Sal Com. Fontanum.
3. Sal Com. Lac. Med.
4. Sal Com. Gypſeum.
5. Sal Com. Carbonar.

Species.
6. Sal Gem. Griſeum.
7. Sal Gem. Rubrum.
8. Sal Gem. Coerulum.
9. Sal Gem. Flavum.
10. Sal Gem. Nigrum.

Genus 9. SAL AMMON. COMMUNE.

Species.
1. Sal Am. Nat. Gris.
2. Sal. Am. Nat. Nigr.

Species.
3. Sal Am. Nat. Viride.
4. Sal Am. Nat. Rubrum.

Genus 10. BORAX.

Species.
1. Borax.
2. Borax Tincal.

Species.
3. Borax Saxonica.

Vitriolated tartar is found combined with moulds, and clays, which form two ſpecies of it.

Common ſalt has ſeveral varieties under the above ſpecies, according to the ſtrength of the ſolutions, and the bodies with which it is combined, or mixed, when in a ſolid ſtate.

The firſt ſpecies of the tenth genus is borax in its native ſtate, as found in Thebit; the ſecond, is borax, as brought from India; and, the third, is native borax, as lately found in Saxony.

DIVIS. II. EARTHY SALTS.

Genus 1. GYPSA.*

Species.
1. Gypſum Fibroſum.*

Species.
2. Selenites.*

Genus 2. SAL CATHARTICUM AMARUM.

Species.
1. Sal Epſom Oceani.
2. Sal Epſom Fontanum.

Species.
3. Sal Epſom Parietum.

Genus 3. ALUMEN.

Species.
1. Al. Nativ. Fontanum.
2. Al. Nativ. Lacorum.

Species.
3. Al. Nativ. Argillaceum.
4. Al. Nativ. Pyriticum.

Genus 4. MINERA ALUMINIS.

Species.
1. Petra Aluminaris.
2. Argilla Aluminaris.
3. Shiſtus Aluminaris.

Species.
4. Min. Al. Solfatera.
5. Min. Al. Bituminos.

The firſt ſpecies of the laſt genus is found at La Tolfa, and is the pureſt of all the aluminous ores. The ſecond, is found in mines that have been expoſed to the air. The third, has a mixture of foſſil oil. The fourth, is in the form of a whitiſh earth. And, the fifth, has various colours, according to the proportions of the bitumen, ſulphur, and iron, with which it is mixed.

DIVIS. III. METALLIC SALTS.

Genus 1. TURPETHUM MINERALE.

Species.
1. Vit. Mar. Mercuri.* Incertum.

Genus 2. VITRIOLUM COERULUM.

Species.
1. Cupr. Aqua Solut.

Species.
2. Min. Cupr. Sulphurat.

Genus 3. VITRIOLUM VIRIDE.

Species.
1. Pyr. Fer. Car. Fodin.
2. Lap. Atramentarius.

Species.
3. Pyr. Fer. Calcarius.
4. Pyr. Fer. Aqua Solutus.

Genus 4. VITRIOLUM ALBUM.

Species.
1. Vit. Zinci Nativum.
2. Vit. Zinci Goſlarenſe.

Species.
3. Vit. Zinci Cryſtal.
4. Vit. Zinci Aqua Solut.

It is ſaid, that turpeth mineral is found among mercurial ores.

The firſt ſpecies of the ſecond genus is found diſſolved in mineral waters; and, the ſecond, combined with ſulphur and copper ores.

Of the third genus, the firſt ſpecies is found native in mines. The ſecond, is a ſmall round ſtone almoſt entirely ſoluble in water, and which contains ſome copper, or zinc. The third, is a green calcareous pyrites; and, the fourth, is found in mineral waters, in which copper is diſſolved.

It is ſaid that vitriols of ſilver, mercury, lead, cobalt, and nickel are found in the form of effloreſcences among the ores of theſe bodies.

ORDER III. SALINE LAVAS.

Genus 1. LAVA S. CELLULARIA.

Species.	Species.
1. S. Lava Cel. Flava.	2. S. Lava Cel. Viridis.

Genus 2. LAVA S. COMPACTA.

Species.	Species.
1. S. Lava Comp. Griſea,	2. S. Lava Comp. Fuſca.

Genus 3. LAVA S. VITREA.

Species.	Species.
1. S. Lava Vit. Coerula.	2. S. Lava Vit. Viridis.

Genus 4. S. SEMILAVA.

Species.	Species.
1. Semilava S. Flava.	2. Semilava S. Viridis.

When ſaline bodies are melted by volcanic fires, they give the ſpecies of the above genera. As they are commonly combined with earthy bodies, they may be placed here, or in the firſt claſs, without producing any confuſion. The pieces of ſemilavas which do not give fire with ſteel belong to the ſiliceous claſs. Lavas are decompoſed when expoſed for many years to the air, as well as baſaltes and many other foſſils, both earthy and ſiliceous.

ORDER IV. SALINE PETREFACTIONS.

Genus 1. PETREFACTA VEG. SAL.

Species.
1. Mineralis Veg. Alum.
2. Pyrit. Lithoxyloid.
3. Ochra Arb. Petreficat.

Species.
4. Arb. Foſ. Carbonariae.
5. Lignum Foſſile.

Genus 2. PETREFACTA ANIM. SAL.

Species.
1. Conch. Aluminoſa.
2. Conch. Pyritoſa.
3. Conch. Ferrea.
4. Conch. Calcinata.
5. Conch. Abraſa.
6. Conch. Eroſa.
7. Conch. Diſtorta.
8. Arena Conchacea.
9. Gimma.
10. Anthropolithi.
11. Xyloſtea Humana.
12. Zoolithi.
13. Xyloſt. Quadruped.
14. Ebur Foſſile.
15. Turcoſae.
16. Ornitholithi.
17. Xyloſtea Avium.
18. Ichthyolithi.
19. Xyloſtea Piſcium.
20. Gloſſopetrae
21. Bufoniti.

Species.
22. Amphibiolithi.
23. Xyloſtea Amphib.
24. Entomolit. Pterygii.
25. Aſtacolithi.
26. Belemniti.
27. Trochitae.
28. Entrochitae.
29. Entrochi Ramoſi.
30. Aſteriae.
31. Encrini.
32. Ichtyotypolithi.
33. Amphibiotypolithi.
34. Entomotypolithi.
35. Araneae Icones.
36. Corp. Hum. Vitrioliſ.
37. Anim. Muriâ Condita.
38. Pet. Anim. Pyritacea.
39. Pet. Anim. Ferrea.
40. Pet. Anim. Cuprea.
41. Pet. Anim. Argenta.

The three firſt ſpecies of the firſt genus are produced by ſaline bodies, which enter the pores of vegetables; and, as their particles rot, or are diſplaced, preſerve a ſimilar arrangement. When they do not enter their pores, but cover them externally, they are incruſtations. The fourth ſpecies is charcoal, which ſeems to have been formed by ſubterraneous fires. And, the fifth, is wood, which has been preſerved unchanged by ſaline bodies.

Shells, that have been mineralized by ſaline bodies, make the firſt nine ſpecies of the ſecond genus. The remaining ſpecies are the petrefactions of entire animal bodies, or of parts of them, which ſaline bodies have preſerved, either by imbibing the particles that tended to putrefaction, or, by covering them in ſuch a manner, as that the neighbouring bodies could not decompoſe them.

CLASS III.

MINERAL AIR.

ORDER I. SIMPLE AIR.

Genus I. AER PURUS.

Species.	Incertum.

It is ſaid that native pure air has been diſcovered in ſome mines, where the mineral acids could act upon metallic, and calcareous earths, when naturally heated by pyritical bodies.

ORDER II. COMPOUND AIR.

Genus 1. AER COMMUNIS.

Species.
1. Aer Communis.

Species.
2. Aer Com. Denſior.

Genus 2. AER AQUEUS.

Species.
1. Aer Aq. Communis.

Species.
2. Aer Aq. Fodinarius.

Genus 3. AER EFFLUVIOSUS.

Species.
1. Aer Pyriticus.

Species.
2. Aer Bituminoſus.

Genus 4. AER MEPHITICUS.

Species.
1. Aer Meph. Pellucid.

Species.
2. Aer Meph. Albeſcens.

Genus 5. AER INFLAMMABILIS.

Species.
1. Aer Inflam. Albeſc.

Species.
2. Aer Inflam. Fuſcus.

Genus 6. AER PULMONICUS.

Species.
1. Aer Pul. Communis. Incertum.

Genus 7. AER ADUSTUS.

Species.
1. Aer Aduſt. Commun. Incertum.

The firſt genus of this diviſion reaches to the bottoms of the deepeſt mines; increaſing in denſity, according to an invariable law.

A greater denſity of the air in mines, and other circumſtances, make it hold a greater quantity of water, than the air on the ſurface of the earth. This genus therefore conſiſts of two ſpecies, according to the depth, and nature, of the mine.

The various bodies which are decompoſed in mines, by nature, and by art, form the ſpecies of the third genus.

Choke damp makes the fourth genus; and, it is pellucid, or of a grey colour. The laſt has two varieties; the firſt of which is called by miners, on account of its ſmell, the peaſe-bloom damp; and, the ſecond, on account of its ſhape, and ſize, the foot-ball damp.

Fire damp, which makes the fifth genus, is clear, or whitiſh; and it has ſeveral varieties.

Miners, together with the labouring beaſts, and fires, which they make uſe of, generate the ſixth, and the ſeventh genus.

CLASS IV.

MINERAL INFLAMMABLES.

ORDER I. PHLOGISTON.

As the principle of inflammability exiſts in great quantities in foſſil bodies, there can be no doubt but this order belongs to Mineralogy.

ORDER II. CAMINAIA.

Genus 1. ADAMAS GEMMA.

Species.
1. Adamas Ormos.
2. Adamas Flavus.
3. Adamas Rubeſc.

Species.
4. Adamas Virid.
5. Adamas Coerul.
6. Adamas Cubic.

Genus 2. PLUMBAGO.

Species.
1. Plumbago Compacta.
2. Plumbago Mollis.

Species.
3. Plumbago Lutea.
4. Plumbago Squam.

The firſt ſpecies of the firſt genus, is the hardeſt and the moſt pellucid, of all bodies; for it cuts rubies, and is brilliant without colour. It is found cryſtallized in an octogonal form, and, likewiſe, in round maſſes. The properties of the other ſpecies are denoted by their names. Their component parts, and hardneſs, are marked in page 37, and in page 106.

Cloſeneſs of texture, hardneſs, and colour diſtinguiſh the ſpecies of the ſecond genus; ſome of which contain, in 100 grains, about 67 of phlogiſton, and 33 of mephitic air.

DIVIS. I. INFLAMMABLE AIR.

Genus 1. AER FODINARUM IGNEUS.

Species.
1. Aer Fod. Ig. Ferreus.

Species.
2. Aer Fod. Ig. Hepaticus.

The firſt ſpecies of inflammable foſſil air is produced by a mixture of the vitriolic acid, iron, and water, which are three bodies that abound in the earth; and, the ſecond, by ſulphur diſſolved in the vitriolic air, or in the marine air. There are many varieties of factitious inflammable air; and, from the accounts of miners, it ſeems probable that there are ſome varieties of foſſil inflammable air, which have not been examined.

DIVISION. SULPHUR.

Genus 1. SULPHUR PURUM.

Species.	Species.
1. Sul. Nat. Petroſum.	4. Sul. Nat. Spiculatum.
2. Sul. Nat. Gypſeum.	5. Sul. Nat. Quartozum.
3. Sul. Nat. Cryſtallis.	6. Sul. Nat. Cloacinum.

Genus 2. SULPHURIS MINERA.

Species.	Species.
1. Min. Sulph. Argillac.	4. Min. Sulph. Alkalina.
2. Min. Sulph. Selenit.	5. Min. Sulph. Pyritica.
3. Min. Sulph. Calcarea.	6. Min. Sulph. Metallica.

Sulphur is found native in the veins of rocks, in gypſa, in the form of octogonal or rhomboidal cryſtals, or of ſmall needles, or in the cavities of quartz, or in old ſewers.

The minerals or combinations of ſulphur, are with clay, ferrugenous ſelenites, limeſtone, alkali in waters, pyrites, metallic bodies; and, of theſe ſix ſpecies, there are many varieties.

DIVISION. FOSSIL CHARCOAL.

Genus 1. CARBO LIGNARIUS FOSS.

Species. *

Species. *

Genus 2. CARBO ANIMALIS FOSS.

Species. *

Species. *

The ſpecies of theſe two genera are included among the petrefactions. Wood, and the bones of animals, are found reduced to aſhes at ſuch depths in the earth, and in ſuch quantities, that the changes upon them ſeem to have been the effect of volcanic fires.

DIVISION. FOSSIL OIL.

Genus 1. NAPHTA.

Species.
1. Naphta Pellucida.

Species.
2. Naphta Fuſca.

Genus 2. PETROLEUM.

Species.
1. Petroleum Fuſcum.
2. Petroleum Flavum.

Species.
3. Petroleum Viride.
4. Petroleum Nigrum.

Genus 3. MALTHA.

Species.
1. Maltha Nigra.
2. Maltha Fuſca.

Species.
3. Maltha Rubra.
4. Maltha Coerula.

Genus 4. ASPHALTUM.

Species.
1. Aſphaltum Nigrum.
2. Aſphaltum Fuſcum.

Species.
3. Aſphaltum Mumia.
4. Aſphaltum Kodreti.

Genus 5. GAGATES.

Species.
1. Gagates Nitens.

Species.
2. Gagates Fuſcus.

Genus 6. LITHANTHRAX.

Species.
1. Carbo Fod. Cannel.
2. Carbo Fod. Kilken.
3. Carbo Fod. Bitumin.
4. Carbo Fod. Pyriticus.

Species.
5. Carbo Fod. Compact.
6. Carbo Fod. Terreus.
7. Carbo Fod. Flexilis.

Genus 7. GEANTHRAX.

Species.
1. Geanthrax Niger.
2. Geanthrax Fuſcus.
3. Geanthrax Vegetab.

Species.
4. Gean. Bituminos.
5. Turfa Niger.
6. Turfa Fuſca.

Genus 8. SUCCINUM.

Species.
1. Succin. Pellucidum.
2. Succin. Opacum.
3. Succin. Aurantium.

Species.
4. Succin. Albeſcens.
5. Suc. Vegetab. Contin.
6. Suc. Animal. Contin.

Genus 9. AMBERGRISEUM.

Species.
1. Ambergr. Flavum.
2. Ambergr. Maculat.

Species.
3. Ambergr. Nigrum.
4. Ambergr. Fuſcum.

The component parts of this diviſion, are marked in pages 17, 18, 39.

When the firſt ſpecies of the firſt genus, iſſues from rocks, it is pellucid, and fragrant; but, when expoſed to the air, it acquires a brown colour, and then it makes the ſecond ſpecies.

Naphta makes the baſis of the ſecond genus; and, according to the time of its expoſure to the air, and the bodies with which it is mixed in the earth, it forms all the ſpecies of this genus.

If petroleum paſſes through calcareous ſtrata, or floats upon water, it acquires different colours, and forms maltha, with its ſpecies.

The two firſt ſpecies of aſphaltum are ſmooth, hard, brittle, and of a ſhining ſurface when broken. The third, reſembles tallow. And, the fourth, has a mixture of petroleum.

Gagates receives a good poliſh, but there is a difference in its luſtre, which makes two ſpecies.

Pitcoal is the ſixth genus. The firſt ſpecies breaks in all directions, burns with a bright flame, and, its ſpecific gravity is about 1,27. The ſecond, contains a greater proportion of petroleum, and burns with leſs flame, and ſmoke. The third, breaks with a rough ſurface, and contains petroleum, argillaceous earth, and ſome volatile alkali. The fourth, is mixed with iron, pyrites, and ſulphur. The fifth, is the beſt of all the pitcoals, being in ſolid maſſes, having no pyrites, and burning with a ſtrong, bright flame, with hardly any ſmell, and aſhes. The ſixth, is in ſmall maſſes, like common earth, contains ſulphur, or bitumen, and burns ſlowly, with little flame. The ſeventh, is lamellar and flexile, when firſt taken out of the earth; and, ſeems to be wood which has been penetrated by petroleum, alum, and vitriol.

Peat that is black, and cloſe in its texture, makes the firſt ſpecies of the ſeventh genus. Beſides vegetables, it contains a great variety of bodies, and in different proportions; ſuch as calcareous, and argillaceous earth, pyrites, common ſalt, volatile, and fixed alkali. The ſecond ſpecies is brown, owing to different proportions of theſe bodies. The third, has a greater mixture of plants. The fourth, is viſcid, and contains much foſſil oil. The fifth, and ſixth, are full of vegetable roots, which are not decompoſed, and have not been long expoſed to the air.

The diſtinctions in the ſpecies of amber, are obvious from their names; and, the two laſt contain vegetable, and animal bodies, or parts of them.

It has been long known that there are parts in a whale, which are like the muſk of land animals; and it has been lately obſerved, that when honeycombs lie long in the ſea, they acquire the appearance of ambergris; on which account they make a ſpecies of this genus.

Noctilucae have been obſerved in mines, but have not been examined; ſo that it is unknown whether they are electric matter, or fire-damp burning ſlowly, or a light ariſing from the action of foſſil bodies upon each other; in which laſt caſe, they are true noctilucae, or perhaps phoſphori.

CLASS V.

METALLIC FOSSILS.

DIVIS. I. METALS.

METALS.

1. Aurum.
2. Platina.
3. Argent. Vivum.
4. Argentum.
5. Cuprum.
6. Ferrum.
7. Stannum.
8. Plumbum.

All the metals have been found in a native ſtate; but ſome of them in very ſmall quantities.

Native gold is found in irregular maſſes joined to quartz; or, in the form of grains mixed with ſand; or, of duſt mixed with earths of every kind; and ſo univerſally, though in ſmall quantities, that, excepting iron, it is more common in the earth than any other metal.

Platina is in large, ſmooth, grains; or, mixed with quartz and ferrugenous ſand. Theſe are ſaid to be the two forms in which it is found native; but it is doubtful whether that is its original ſtate.

Mercury is found native in a fluid ſtate; or joined to ſilver; or diffuſed in clays of different colours.

The forms of native ſilver are granular, arboreſcent, filamentous, lamellar, capillary, cryſtallized, or in ſeparate maſſes.

Native copper is found foliated, capillary, arboreſcent, or cryſtallized in quadrangular pyramids, or in detached lumps.

Iron is found in a native ſtate, in grains, and in maſſes of very different ſizes.

Tin is found native in thin, flexile plates, lodged in quartz, or regularly cryſtallized.

Native lead is found in ſmall pieces.

DIVIS. II. SEMI-METALS.

1. Biſmuthum.
2. Nickelum.
3. Zincum.
4. Reg. Antimonii.
5. Reg. Arſenici.
6. Reg. Cobalti.
7. Reg. Syderitis.
8. Reg. Manganeſi.
9. Reg. Molybdenae.

Of the nine ſemi-metals, the third, and the laſt four, have not been found in a native ſtate.

Biſmuth is found native in the form of cubes, or of octagons, or of thin plates covering the ores of other metals.

Native nickel has been found in a mine of cobalt; and, in the form of a green calx, mixed with calx of iron.

Regulus of antimony has been found native, in the form of ſhining, white, irregular plates.

Native reg. of arſenic has been found in ſmall quantities, with a friable, and ſcaly texture.

DIVIS. III. ORES.

SUBDIVIS. I. ORES OF METALS.

Genus 1. MINERA AURI.

Species.
1. Pyrit. Mart. Auri.

Species.
2. Pyrit. Arſen. Auri.

Species.

3. Vitr. Argen. Auri.
4. Sul. Min. Arg. Auri.

Species.

5. Min. Mangan. Auri.
6. Ter. Peruv. Auri.

Genus 2. MINERA PLATINAE.

Species.

1. Plat. Quart. Ferrum.

Incertum.

Genus 3. MINERA MERCURII.

Species.

1. Mercur. Aeratus.
2. Vitriolmart. Merc.
3. Cinnabar. Nativ.

Species.

4. Min. Mer. Sulph. Cupr.
5. Min. Mercur. Pyrit.

Genus 4. MINERA ARGENTI.

Species.

1. Argen. Sulph. min.
2. Argen. Arſen. min.
3. Argen. Quadanal.
4. Min. Arg. Rubra.
5. Min. Arg. Ferrea.
6. Pyrites Argenteus.
7. Min. Arg. Alba.
8. Min. Arg. Griſea.

Species.

9. Min. Arg. Fuſca.
10. Min. Arg. Plumoſa.
11. Min. Arg. Cobaltica.
12. Min. Arg. Barytica.
13. Min. Arg. Phlogiſt.
14. Min. Arg. Cornea.
15. Min. Arg. Anſerina.
16. Min. Arg. Foliacea.

Genus 5. MINERA CUPRI.

Species.

1. Min. Cupr. Hepat.
2. Malchites.
3. Chryſocolla.
4. Min. Cupr. Vitrea.
5. Min. Cupr. Coerul.
6. Min. Cupr. Flava.

Species.

7. Min. Cupr. Griſea.
8. Min. Cupr. Blendoſa.
9. Min. Cupr. Shiſtoſa.
10. Min. Cupr. Bitumin.
11. Min. Cupr. Vitriolata.
12. Min. Cupr. Muriat.

Genus 6. MINERA FERRI.

Species.

1. Minera Chalybea.
2. Magnes.
3. Min. Fer. Plumbag.
4. M. Fer. Manganeſa.
5. Arena Magnetica.
6. Hæmatites.
7. Hæmatites Ochrea.
8. Plumbagea Rubra.
9. Min. Forſten.
10. Arena Emery.
11. Min. Fer. Griſea.
12. M. Fer. Montana.
13. M. Fer. Lacuſtris.

Species.

14. Min. Fer. Calcarea.
15. Min. Fer. Silicea.
16. Min. Fer. Muriatica.
17. Min. Fer. Calaminar.
18. Pyrit. Martial. Flava.
19. Marcaſites.
20. Min. Fer. Miſpickel.
21. Min. Fer. Phlogis.
22. Min. Fer. Vitriolica.
23. Coerul. Pruſs. Nativ.
24. Terra Veronica.
25. Fer. Blende.

Genus 7. MINERA STANNI.

Species.

1. Min. Stan. Alba.
2. Min. Stan. Nigra.

Species.

3. Min. Stan. Rubra.
4. Lapis Stanni.

Genus 8. MINERA PLUMBI.

Species.

1. Ceruſſa Nativa.
2. Min. Plumb. Cryſtal.
3. M. Plumb. Spiculata.
4. M. Plumb. Viridis.
5. M. Plumb. Coerula.
6. M. Plumb. Nigra.
7. M. Plumb. Vitriol.

Species.

8. Min.Plumb.Phoſphor.
9. Galena Communis.
10. Min. Plumb. Antim.
11. M. Plumb. Arg. Pyr.
12. M. Pl. Arg. Arſen.
13. M. Plumb. Calcarea.
14. M. Plumb. Barytica.

The component parts of the ſpecies in this diviſion, are obvious from their names, or are well known; except the following.

Arſenic and ſilver, in very unequal parts, make the third ſpecies of the fourth genus, which, when cut, has a bright metallic appearance. The fourth, is ſilver mineralized by ſulphur, and arſenic. The fifth, by ſulphur, arſenic, and iron. The ſixth, by arſenic, and iron. The ſeventh, by arſenic, ſulphur, and iron. The eighth, by the ſame bodies, in greater proportions. The ninth, by the ſame, and reg. of antimony. The tenth, by ſulphur, arſenic, iron, and reg. of antimony; and, the varieties of it are capillary, ſoft, looſe, and fixed. The thirteenth, is pitcoal in which ſilver is found. The ſixteenth, is the aluta montana, with which ſilver is united.

The ſecond ſpecies of the fifth genus is green, and does not ſtrike fire with ſteel: 100 parts of it contain about 75 of copper, and 25 of mephitic air in water. The fourth, fifth, and ſixth ſpecies, differ from each other, by the proportions which they contain of ſulphur, and iron. The ſeventh, is copper mineralized by ſulphur, arſenic, and iron. The eighth, by the ſame bodies, with zinc.

There are ſeveral varieties of the ſecond ſpecies of the ſixth genus, which ariſe from hardneſs, ſize, and colour. Such of them as have the ſtrongeſt magnetic powers, reſemble baſaltes, and, are found near the ſurface of the earth. The firſt of the laſt three ſpecies is clay mixed with iron, and a blue ſubſtance found in ſwampy ground.

SUBDIVIS. 2. ORES OF SEMI-METALS.

Genus 1. MINERA BISMUTHI.

Species.
1. Min. Biſmuth. Vit.
2. Min. Biſmuth. Sulph.

Species.
3. Min. Biſmuth. Mart.

Genus 2. MINERA NICKELI.

Species.
1. Nickel Vitriolat.

Species.
2. Nickel Arſenicum.

Genus 3. MINERA ZINCI.

Species.
1. Min. Zinci Vitrea.
2. Zincum Tutenago.
3. Min. Zinci Calam.
4. Min. Zinci Silicea.
5. Min. Zinci Vitriol.
6. M. Zin. Galenacea.
7. Zin. Glanzblende.

Species.
8. Zin. Peecheblende.
9. Min. Zin. Rodſlag.
10. Zin. Phos. Blende.
11. Zin. Blendgriſeum.
12. Zin. Blendalbum.
13. Zin. Blendflavum.

Genus 4. MINERA ANTIMONII.

Species.
1. Min. Ant. Arſenica.

Species.
2. Min. Antimon. Varia.

Genus 5. MINERA ARSENICI.

Species.
1. Arſen. Calciforme.
2. Arſen. Sul. Flavum.
3. Arſen. Sul. Rubrum.

Species.
4. Pyrit. Arſen. Griſeum.
5. Pyrit. Arſen. Calcar.

Genus 6. MINERA COBALTI.

Species.
1. Min. Cobalti Aerata.
2. Min. Cob. Vitriolica.

Species.
3. Min. Cobalti Arſen.
4. Min. Cobalti Martial.

Genus 7. MINERA SYDERITIS.

Species.
1. Syderit. Fer. Fuſi.

Species.
2. Syder. Fer. Coldſhort.

Genus 8. MINERA MANGANESI.

Species.
1. Min. Mangan. Alba.
2. Min. Mang. Rubra.

Species.
3. Min. Manganes. Fuſca.
4. Min. Mang. Blackwad.

Genus 9. MINERA MOLYBDENAE.

Species.
1. Molyb. Membranac.

Species.
2. Molyb. Barytica.

The firſt ſpecies of the third genus contains, in 100 grains, about 65 of the calx of zinc, 28 of mephitic air, 6 of water, and 1 of iron. The ſecond, about 90 of zinc, and 10 of argillaceous earth and iron. The third, 84 of zinc, 3 of iron, 1 of argillaceous earth, and 12 of ſiliceous; but theſe proportions differ greatly in the varieties. The ſixth, contains a mixture of lead ore, and ſulphur. The ſeventh, in 100 parts, about 52 of zinc, 8 of iron, 4 of water, and 6 of the ſiliceous earth. The eighth, is a compound of ſilver, arſenic, and other metallic bodies. The ninth, contains various proportions of zinc, iron, ſulphur, water, quartz, and argillaceous earth. The tenth, contains iron, ſulphur, water, ſiliceous earth, and ſpar acid.

Silver, and other metallic bodies are contained in the firſt ſpecies of the fourth genus. The various ores which contain antimony are comprehended under the ſecond ſpecies, as varieties.

The firſt ſpecies of the ſeventh genus, is found chiefly in caſt iron; and, the ſecond, in the ores of coldſhort iron.

Manganeſe ores contain various proportions of mephitic air, iron, calcareous, ponderoſa, and ſiliceous earths. The laſt ſpecies contains, in 100 parts, about 43 of manganeſe, 43 of iron, 4 of lead, 5 of mica, and 5 of mephitic air, or of ſome other bodies, which are loſt in making the analyſis.

The firſt ſpecies of the laſt genus, reſembles plumbago; but, its ſcales are larger, and of a bright leaden colour: 100 parts of it contain about 55 of ſulphur, and 45 of the acidum molybdenae.

CLASS VI.

WATER.

ORDER I. SIMPLE WATER.

Genus I. AQUA PURA.

Species.	Species.
1. Aq. Pura Terreſtris.	2. Aq. Meteorica Terres.

The water of this order is tranſparent, and without taſte, and ſmell. It is only ſimple, when compared to the next order, and, when no art is uſed to decompoſe it. The firſt ſpecies is that which is found on the ſurface, or in the bowels of the earth, and is pureſt when it paſſes through a bed of fine ſand. The ſecond, is that which has juſt fallen on the earth, in the form of dew, rain, hail, or ſnow. It yields, by a ſimple diſtillation, a ſmall proportion of calcareous earth, nitre, common ſalt, and oil; beſides the heterogeneous matter which floats in the atmoſphere, near the habitations of men.

ORDER II. COMPOUND WATER.

DIVIS. I. EARTHY WATER.

Genus 1. AQUA CALCAREA.

Species.
1. Aqua Calc. Salina.
2. Aqua Calc. Aerata.

Species.
3. Aqua Calc. Glaubera.
4. Aqua Calc. Oleoſa.

Genus 2. AQUA PONDEROSA.

Species.
1. Aq. Pon. Petrefaciens.

Species.
2. Aq. Pon. Stalactit.

Genus 3. AQUA MAGNESIA.

Species.
1. Aq. Magn. Aerata.

Species.
2. Aq. Magn. Argil.

Genus 4. AQUA ARGILLACEA.

Species.
1. Aq. Argil. Salina.

Species.
2. Aq. Argil. Aerata.

Genus 5. AQUA SILICEA.

Species.	Species.
1. Aq. Silicea Calc.	2. Aq. Silicea Argil.

The genera of this diviſion, with their ſpecies, and varieties, are found in many countries; and, in ſome of the ſpecies, the component part from which it takes its name, is in ſo ſmall a quantity, as to require a careful analyſis, before it can be diſcovered.

DIVIS. II. SALINE WATER.

Genus 1. AQUA ACIDA.

Species.	Species.
1. Aqua Vitriolica.	2. Aqua Muriatica.

Genus 2. AQUA ALKALINA.

Species.	Species.
1. Aqua Natroſa.	2. Aqua Natr. Chalybea.

Many waters are found, which contain the vitriolic and muriatic acids, the foſſil alkali, and other bodies, in various proportions.

DIVIS. III. AERATED WATER.

Genus 1. AERPURA AQUA.

Species.	Species.
1. Aerpur. Aq. Terreſt.	2. Aerp. Aq. Meteorica.

Genus 2. AERCOMPOSITA AQUA.

Species.	Species.
1. Aercomp. Aq. Terreſt.	2. Aercomp. Aq. Meteor.

Pure air, common air, and mephitic air, are found in water, and they form ſeveral varieties, according to their proportions, and the bodies with which they are combined.

DIVIS. IV. PHLOGISTIC WATER.

Genus 1. AQUA OLEOSA.

Species.	Species.
1. Aqua Petrolea.	2. Aqua Aſphaltica.

Genus 2. AQUA PUTREFACTA.

Species.	Species.
1. Aq. Putr. Vegetabilis.	3. Aq. Oleoſa Inflam.
2. Aq. Putr. Animalis.	4. Aq. Aerata Inflam.

Genus 3. AQUA SULPHUREA.

Species.	Species.
1. Aq. Sul. Alkalina.	3. Aq. Sul. Salina.
2. Aq. Sul. Glaubera.	4. Aq. Sul. Mixta.

Foſſil oil is found in many waters, which have different names, according to the ſtate of the oil.

The firſt ſpecies of the ſecond genus is found in river water, and in veſſels made of green wood, which contain rain, river, or ſpring water. The ſecond, is produced by water that contains putrid animal ſubſtances. The third, by foſſil oil, on the ſurface of wells. And, the fourth, by inflammable air, floating upon ſtagnant water. The laſt two are called putrid, on account of their ſmell, but improperly.

When ſulphureous water contains foſſil alkali, or glauber's ſalt, or common ſalt, or mixtures of various bodies, it forms the four ſpecies of the third genus.

DIVIS. V. METALLIC WATER.

Genus 1. AQUA CUPREA.

Species.
1. Aq. Cuprea Viridis.
2. Aq. Cuprea Coerula.

Species.
3. Aq. Cuprea Alba.

Genus 2. AQUA FERREA.

Species.
1. Aq. Chalyb. Pellucid.
2. Aq. Chalybea Rubra.

Species.
3. Aq. Chal. Vitriolica.
4. Aq. Chalybea Mixta.

Some waters contain ſo much copper, that it is precipitated, when pieces of iron are laid in them. The ſpecies are denominated from the colour of the vitriols which they produce. Some of them contain likewiſe ſmall portions of ſeveral other bodies.

Iron is ſuſpended in water, in various forms, by mephitic air. When it makes the firſt ſpecies, it is only diſcovered by the taſte, or the mixture of other bodies. The ſecond, precipitates the iron, without any mixture. The third, contains vitriol at the ſame time. And, the fourth, a mixture of various bodies, which form many varieties, under theſe ſpecies.

CLASS VII.

FIRE.

Fire, and its genera, ſee page 22, with many ſpecies of them which are obvious, is conſtantly found in the earth.

The firſt genus exiſts in foſſils, as is proved by their decompoſition. The ſecond, appears from the permanent warmth in the earth, from the heat generated by pyrites, and, other foſſils, and from the hot ſprings, which are cauſed by the flowing of water through ſtratums of ſhiſtus, or of blue marl, mixed with pyrites. The two laſt genera are obvious from the bodies which have burned in the earth for many ages, and from volcanos, and lavas.

SECT. II,

OF OTHER SYSTEMS OF FOSSILS.

Of the writers on Mineralogy, and their ſyſtems, prior to the fall of the Roman Empire; and, from that era, to the end of the laſt century; and, from it to the preſent time.

SECT. III.

OF THE STRUCTURE OF THE EARTH.

The ſurface of the earth is covered with oceans, ſeas, rivers, lakes, moulds, ſand, moraſſes, rocks; and the proportion of the ſurface of water of every kind, to the ſurface of land, is thought, by a rude computation, to be as three to one.

The ſurface of the land is divided into plains, vallies, hills, and mountains; which are either primeval, or alluvial.

Hills bear the obvious marks of alluvions; and, their interior parts are compoſed of ſand, and ſtones, and ſtrata, like ſome of thoſe in mountains, and in mines.

Mountains, as to their internal ſtructure, are of three kinds; ſuch as are compoſed of maſſes, of ſtrata, or of mixts.

The firſt kind, conſiſts chiefly of granite, ſhiſtus, flag-ſtone, ſand-ſtone, lime-ſtone, gypſum, porphyry, or trapp; and ſome almoſt entirely of iron ore.

The ſecond kind, have regular fiſſures, and are homogeneous, or heterogeneous; their poſition being conſidered with regard to the horizon, and the meridian of the place. The homogeneous, conſiſt chiefly of argillaceous ſtones, and of ſcaly lime-ſtone. The metallic ores are commonly found among them in veins, and not in ſtrata. The calcareous ſeldom contain any ore, and when they do, it is that of iron, copper, lead, or mercury. The heterogeneous, conſiſt alternately of calcareous, and argillaceous bodies, or both, or metallic ores, and ſometimes of lava.

The third kind of mountains, are compoſed of ſtones of all ſorts, lying together without any order, and having their interſtices filled with ſand, clay, mica; and it is ſeldom that ſuch contain any ores.

Petrified ſhells are found near the ſurface of the earth, in vallies, and in hills; and great quantities of them are found in beds, at conſiderable depths. Petrified fiſhes are found at a greater depth, and petrified wood, at a ſtill greater. Both vegetable, and animal petrefactions are found in calcareous, and argillaceous ſtrata; but, not in granite, baſaltes, or ſhoerl. They are found likewiſe among metallic ores, and the leaſt valuable gems; and, when in ſlate, or clay, they are compreſſed, and mutilated. They are often found in climates, where living bodies, of the ſame kind, do not exiſt at preſent.

Mountains are of very different heights. The higheſt are in South America. The town of Quito is in perpendicular height above the level of the ſea 9242 Engliſh feet. The mountain Coraſſo is 15783 feet; and Chimboraço, the higheſt in the world, is 20575,8 feet; or, 3,89 Engliſh miles. In Africa, Ruivo in Madeira, is 5141 feet; and the Pic of Teneriffe is 11022 feet. In Europe, Veſuvius is 3938 feet; Hecla is 5000; Puy De Dome is 5221; Mont D'Or is 6696; St. Bartelemi is 7565; Canigou is 9214; Etna is 10954; and Mount Blanc, in the Alps, is 15672; or, two Engliſh miles, three quarters, and 4608 feet; Shehallien, in Perthſhire, which is, perhaps, the higheſt in Britain, is only 3550 feet above the level of the ſea. In Aſia, the mountains have not been meaſured with accuracy.

Volcanos are in all climates, and of various heights. The marks of ancient ones are found in inland countries. The modern ones are near the ſea; and ſome of them have lately burſt out of it. The height of ſome volcanos is only 450 feet; but, in general, they are high mountains, and have a cavity near their ſummit, ſhaped like an inverted cone. It has been computed that Veſuvius, from the year 1779, to the year 1783, ejected 309,658,161 cubic feet of matter, of which iron makes between a fourth and a fifth part. Stones of all ſorts, and even of ten, or twelve feet in diameter, have been thrown out of volcanos, and ſometimes to the diſtance of ſeveral miles.

The earth is about 8000 miles in diameter, and bears the ſame proportion to the higheſt mountain, which a globe of two feet in diameter bears to a mote that is viſible in the ſun-beam. Or, if the fineſt hair of a man's head, is equal in thickneſs to the 400 part of an inch, it bears the ſame proportion to a globe of eighty inches, or ſix feet eight inches in diameter, which a mountain of a quarter of a mile in perpendicular height, does to the earth.

SECT. IV.

THEORIES CONCERNING THE EARTH.

Of the different opinions which have been held concerning the chaos, the deluge, and the preſent ſtate of the earth.

A theory of them is given, which is founded upon things that formerly were imperfectly known; namely, the Laws of Gravity, and Hydroſtatics; the variety of vegetable and animal bodies, that are found depoſited at great heights, and depths, in the earth; the art of Mining, and Chemiſtry; the diſtant parts of the earth; and, the cauſes and effects of volcanos, and earthquakes.

BOTANY.

Organized bodies, which give no marks of ſenſation, which propagate their kinds by invariable laws, which grow to maturity, decay, and rot, are the object of this part of phyſics.

SECT. I.

OF THE TRIBES OF VEGETABLES, AND THEIR PARTS.

Of Fungi, Algae, Muſci, Filices, Gramina, Palmae, Plants.

Of the root, herb, trunk, leaves, fulcra, hybernacula, &c.

Of the genera, ſpecific diſtinctions, and varieties in vegetables.

SECT. II.

OF THE PARTS OF FRUCTIFICATION.

Of the calyx, corolla, ſtamina, piſtillum, pericarpium, ſeed, and receptacle.

Of aggregate and luxuriant flowers.

Of the ſex of plants.

SECT. III.

OF THE SEXUAL SYSTEM.

SECT. IV.

OF OTHER SYSTEMS IN BOTANY.

SECT. V.

THE THEORY OF VEGETATION.

ZOOLOGY

Comprehends all living creatures, or bodies with organized parts, which give marks of ſenſation, which continue their kinds according to invariable laws, and, which are found in the ſtate of embryo, infancy, maturity, old age, or death.

SECT. I.

ANIMALCULES,

Or living creatures which are only viſible by the help of glaſſes.

CLASS I.

GYMNIA.

Animalcules without tails and without limbs.

ORDER I.

ENCHELIDES.

Such as are of a cylindric form.

Genus.
1. En. Radiformis.
2. En. Cylindricus.

Genus.
3. En. Conicus.
4. En. Annulatus.

ORDER II.

CYCLIDIA.

The form of their bodies is circular.

Genus.
1. Cy. Globoſum.
2. Cy. Elipticum.

Genus.
3. Cy. Cuſpidatum.
4. Cy. Spheroidicum.

ORDER III.

PARAMECIA

Are of an irregular oblong form.

Genus.
1. Pa. Maculatum.
2. Pa. Pectenatum.

Genus.
3. Pa. Zonarium.
4. Pa. Pellucidum.

ORDER IV.

CRASPIDARIA

Have a mouth, and ſimbriae.

Genus.
1. Cr. Orbiculare.
2. Cr. Conicum.

Genus.
3. Cr. Cylindricum.

CLASS II.

CERCARIA.

Animalcules which have tails, but no limbs.

ORDER I.

BRACHIURI.

Such as have tails ſhorter than their bodies.

Genus.
1. Br. Orbicularis.

Genus.
2. Br. Ovatus.

Genus.
3. Br. Fimbriatus.
4. Br. Lunatus.

Genus.
5. Br. Cerviculatus.

ORDER II.

MACROCERCI

Have tails longer than their bodies.

Genus.
1. Ma. Cauda Recta.
2. Ma. Cauda Spirali.
3. Ma. Globoſus.
4. Ma. Lachriformis.

Genus.
5. Ma. Anguilar.
6. Ma. Articulatus.
7. Ma. Hamatus.

CLASS III.

ARTHRONIA.

Animalcules which have limbs.

ORDER. I.

SCELASII.

Such as have eliptical bodies.

Genus.
1. Sc. Spheroidicus.

Genus.
2. Sc. Elipticus.

ORDER II.

BRACHIONI

Have articulations, and fimbriae.

Genus.
1. Br. Conicus.
2. Br. Furcillatus.
3. Br. Cylindricus.

Genus.
4. Br. Campaniformis.
5. Br. Lunatus.

Of other animalcules; and the ſpecies of the above.

SECT. II.

ANIMALS,

Or living creatures that are viſible by the naked eye.

CLASS I.

WORMS.

Animals without feet, fins, ears, and red blood.

ORDER I.

LITHOPHYTA.

Worms fixed to, and generating coral.

Genus.
1. Tubipora.
2. Madrepora.

Genus.
3. Millepora.
4. Celepora.

This order contains fifty-nine ſpecies.

ORDER II.

ZOOPHYTA.

Worms reſembling a flower, and coming from a vegetating ſtem.

Genus.
1. Iſis.
2. Gorgania.
3. Alcyonium.
4. Spongia.
5. Fluſtra.
6. Tubularia.
7. Corallina.

Genus.
8. Vorticella.
9. Serticlaria.
10. Hydra.
11. Pennatula.
12. Taenia.
13. Volvox.
14. Furia.

This order contains one hundred and fifty ſpecies.

ORDER III.

INTESTINA.

Worms without a covering, and without limbs.

Genus.
1. Gordius.
2. Aſcaris.
3. Lumbricus.
4. Faſciola.

Genus.
5. Sipunculus.
6. Hirudo.
7. Myxine.

This order contains twenty-four ſpecies.

ORDER IV.

MOLLUSCA.

Worms without a covering, and with limbs.

Genus.
1. Limax.
2. Laplyſia.
3. Doris.
4. Aphrodita.
5. Neris.
6. Achnia.

Genus.
7. Tethys.
8. Holothuria.
9. Terebella.
10. Triton.
11. Lernea.
12. Scyllaea.

Genus.
13. Clio.
14. Sepia.
15. Meduſa.

Genus.
16. Aſterias.
17. Echinus.

This order contains ninety-eight ſpecies.

ORDER V.

TESTACEA.

Worms with ſhells, and moſtly of the above orders.

MULTIVALVES.

Genus.
1. Chiton.
2. Lepas.
3. Pholas.

BIVALVES.

4. Mya.
5. Solen.
6. Tellina.
7. Cardium.
8. Mactra.
9. Donax.
10. Venus.
11. Spondylus.
12. Chama.
13. Arca.
14. Oſtrea.
15. Anomia.
16. Mytilus.
17. Pinna.

UNIVALVES.

18. Argonauta.
19. Nautilus.
20. Conus.
21. Cypraea.
22. Bulla.
23. Voluta.
24. Buccinum.
25. Strombus.
26. Murex.
27. Trochus.
28. Turbo.
29. Helix.
30. Nerita.
31. Haliotis
32. Patella.
33. Dentalium.
34. Serpula.
35. Teredo.
36. Sabella.

This order contains eight hundred and fourteen ſpecies.

CLASS II.

INSECTS.

Animals without ears, and red blood; with lateral jaws, a tongue, eyes, and feelers in the head, and a covering like horn.

ORDER I.

COLEOPTERA.

Such as have four wings, the upper ones cruſtaceous, and which meet together in a ſtraight line on the upper part of the body.

Genus.
1. Scarabaeus.
2. Lucanus.
3. Dermeſtes.
4. Plinus.
5. Hiſter.
6. Gyrinus.
7. Byrrhus
8. Silpha.
9. Caſſida.
10. Coccinella.
11. Chryſomela.
12. Hiſper.
13. Bruchus.
14. Curculio.
15. Attelabus.

Genus.
16. Cerambyx.
17. Leptura.
18. Necydalis.
19. Lampyris.
20. Cantharis.
21. Elater.
22. Cicendela.
23. Bupreſtis.
24. Dytiſcus.
25. Carabus.
26. Tenebrio.
27. Meloe.
28. Mordella.
29. Staphylinus.
30. Forficula.

This order contains eight hundred and ninety-three ſpecies.

ORDER II.

HEMIPTERA.

They have four wings, the two uppermoſt reſembling vellum, covering the body horizontally, and not meeting in a ſtraight line.

Genus.
1. Blatta.
2. Mantis.
3. Gryllus.
4. Fulgora.
5. Cicada.
6. Notonecta.

Genus.
7. Nepa.
8. Cimex.
9. Aphis.
10. Cherines.
11. Coccus.
12. Thrips.

This order contains three hundred and fifty-three ſpecies.

ORDER III.

LEPIDOPTERA.

Such as have wings which are membranaceous, and covered with ſcales.

Genus.
1. Papilio.
2. Sphinx.

Genus.
3. Phalaena.

This order contains ſeven hundred and eighty ſpecies.

ORDER IV.

NEUROPTERA

Have four membranaceous wings, but are not covered with ſcales; and the abdomen has no ſting.

Genus.
1. Libellula.
2. Ephemera.
3. Phryganea.
4. Hemerobius.

Genus.
5. Myrmeleon.
6. Panorpa.
7. Raphidia.

This order contains eighty-three ſpecies.

ORDER V.

HYMENOPTERA.

Such as have four membranaceous wings, without ſcales; and the abdomen has no ſting.

Genus.
1. Cynips.
2. Tenthredo.
3. Sirex.
4. Ichneumon
5. Sphex.

Genus.
6. Chryſis.
7. Veſpa.
8. Apis.
9. Formica.
10. Mutilla.

This order contains three hundred and fourteen ſpecies.

ORDER VI.

DIPTERA

Have two wings, and poiſers inſtead of under wings.

Genus.
1. Oeſtrus.
2. Tipula.
3. Muſca.
4. Tubanus.
5. Culex.

Genus.
6. Empis.
7. Conops.
8. Aſilus.
9. Bombylius.
10. Hippoboſca.

This order contains two hundred and ſixty-two ſpecies.

ORDER VII.

APTERA.

Such as have no wings.

Genus.
1. Lepiſma.
2. Podura.
3. Termes.
4. Pediculus.
5. Pulex.
6. Acarus.
7. Phalanguion.

Genus.
8. Aranea.
9. Scorpio.
10. Cancer.
11. Monoculus.
12. Oniſcus.
13. Scolopendra.
14. Julus.

This order contains three hundred and three ſpecies.

CLASS III.

FISHES.

Animals living in water, and breathing by gills, lungs, or both; and having red blood.

ORDER I.

APODES.

Such as have no ventral fins.

Genus.
1. Muraena.
2. Gymnotus.
3. Trichiurus.
4. Anarhichas.

Genus.
5. Ammodytes.
6. Ophidium.
7. Stromateus.
8. Xiphias.

This order contains twenty ſpecies.

ORDER II.

JUGULARES.

They have ventral fins placed before the pectoral.

Genus.
1. Callionymus.
2. Uranoſcopus.
3. Trachinus.

Genus.
4. Gadus.
5. Blennius.

This order contains thirty-five ſpecies.

ORDER III.

THORACICI.

Such as have ventral fins underneath the pectoral.

Genus.
1. Cepola.
2. Echeneis.
3. Corypha.
4. Gobius.
5. Cottus.
6. Scorpaena.
7. Zeus.
8. Pleuronectes.
9. Chaetodon.

Genus.
10. Sparus.
11. Labrus.
12. Sciana.
13. Perca.
14. Gaſteroſt.
15. Scomber.
16. Mullus.
17. Trigla.

This order contains two hundred and twenty-one ſpecies.

ORDER IV.

ABDOMENALES.

Such as have ventral fins on the abdomen behind the pectoral.

Genus.
1. Cobitis.
2. Amia.
3. Silurus.
4. Teuthis.
5. Loricaria.
6. Salmo.
7. Fiſtularia.
8. Eſox.
9. Elops.

Genus.
10. Argentina.
11. Atherina.
12. Mugil.
13. Exocoetus.
14. Polynemus.
15. Mormyrus.
16. Clupea.
17. Cyprinus.

This order contains one hundred and twenty-ſeven ſpecies.

ORDER V.

BRANCHIOSTEGI

Have vertical tails, the rays of the fins bony, and the branches without oſſicles.

Genus.
1. Baliſtes.
2. Oſtracion.
3. Tetraodon.
4. Diodon.

Genus.
5. Cyclohterus.
6. Centriſcus.
7. Cyngnathus.
8. Pegaſus.

This order contains ſorty-one ſpecies.

ORDER VI.

CARTILAGINEII.

Such as have not vertical tails; and the rays of the fins are cartilaginous.

Genus.
1. Petromizon
2. Raja.
3. Squalus.

Genus.
4. Chimaera.
5. Lophius
6. Acipencer.

This order contains thirty-five ſpecies.

ORDER VII.

CETACEA

Have pectoral fins, the tail parallel to the horizon, breathing apertures on the head, and no claws.

Genus.
1. Monodon.
2. Balaena.

Genus.
3. Phyſeter.
4. Delphinus.

This order contains twelve ſpecies.

CLASS IV.

AMPHIBIA.

Animals which can live on land, or in water; and ſome of which breathe by their lungs, or gills, at pleaſure.

ORDER I.

MANATI.

Such as have fin-like feet; the fore legs ſunk in the ſkin; and the hind ones pointing backwards.

Genus.
1. Trichecus.
2. Phoca.

Genus.
3. Walrus.

This order contains twenty ſpecies.

ORDER II.

REPTILES.

Amphibia which breathe through the mouth by lungs only; and which have four feet.

Genus.
1. Teſtudo.
2. Rana.

Genus.
3. Draco.
4. Lacerta.

This order contains eighty-two ſpecies.

ORDER III.

MEANTES

Breathe by gills, and lungs, and have arms and claws.

Genus 1. Siren.

ORDER IV.

SERPENTES.

They breathe through the mouth by lungs only; and have no feet, fins, nor ears.

Genus.
1. Crotalas.
2. Boa.
3. Coluber.

Genus.
4. Anguis.
5. Amphiſbaena.
6. Caecilia.

This order contains one hundred and thirty ſpecies.

CLASS V.

BIRDS.

Animals which have a bill, only two legs, two wings, and a covering of feathers.

DIVIS. I. LAND BIRDS.

ORDER I.

ACCIPITRES.

Birds which have a ſtraight bill, but hooked at the end, its edges cultrated, and its baſe covered with ſkin; the legs and feet with ſcales; the firſt joint of the middle toe connected with that of the outmoſt by a membrane; and, the inſide of the wings covered with down.

Genus.
1. Vultur.
2. Falco.

Genus.
3. Strix.
4. Lanius.

This order contains eighty-one ſpecies.

ORDER II.

PICAE.

Birds which have the bill hooked from the baſe;

the upper mandible moveable; with two of the toes backward, and two forward.

Genus.
1. Pſittacus.
2. Toucan.
3. Momota.
4. Buceros.
5. Buphaga.
6. Crotophaga.
7. Corvus.
8. Coracias.
9. Oriolus.
10. Gracula.
11. Paradiſaea.
12. Trogon.

Genus.
13. Bucco.
14. Cuculus.
15. Junx.
16. Picus.
17. Jacamar.
18. Alcedo.
19. Sitta.
20. Todus.
21. Merops.
22. Upupa.
23. Certhia.
24. Trochilus.

This order contains three hundred and ſeventy-one ſpecies.

ORDER III.

GALLINACEAE.

Birds which have the bill arched, the upper mandible ſhutting over the edge of the lower; the toes joined at the baſe as far as the firſt joint by a membrane; and, more than twelve feathers in the tail.

Genus.
1. Gallus.
2. Meleagris.
3. Numida.
4. Crax.
5. Pavo.

Genus.
6. Phaſianus.
7. Tetrao.
8. Perdix.
9. Pſophia.
10. Otis.

This order contains fifty ſpecies.

ORDER IV.

COLUMBINAE

Have the bill ſtraight at the baſe, with a ſoft protuberant ſubſtance in which the noſtrils are placed; the tongue entire; the toes divided to the origin; and, the notes plaintive.

Genus 1. Columbus Agreſtis.

There is but one genus of this order. The ſpecies and, varieties are forty.

ORDER V.

PASSERES.

Birds which have three toes before, and one behind.

Genus.
1. Sturmus.
2. Turdus.
3. Ampelis.
4. Colius.
5. Loxia.
6. Emberiza.
7. Tanagra.
8. Tringilla.

Genus.
9. Muſcicapa.
10. Alauda.
11. Motacilla.
12. Ficedulla.
13. Pipra.
14. Parus.
15. Hirundo.
16. Caprimulgus.

This order contains four hundred and thirteen ſpecies.

ORDER VI.

STRUTHICI.

Birds which have their wings ſo imperfect as to be uſeleſs for flying, but which are of ſome advantage in running.

Genus.
1. Didus.

Genus.
2. Struthio.

This order contains four ſpecies.

DIVIS. II. WATER BIRDS.

ORDER VII.

CLOVEN-FOOTED.

Birds which have the bill flat, and widening into a circular form; the noſtrils near the baſe; and, the feet ſemi-palmated.

Genus.
1. Platalea.
2. Palamedea.
3. Mycterea.
4. Cancroma.
5. Ardea.
6. Scopus.
7. Ibis.
8. Numenius.

Genus.
9. Scolopax.
10. Tringa.
11. Charadrius
12. Hamatopus.
13. Jacana.
14. Pratincola.
15. Rallus.
16. Gallinula.

This order contains one hundred and ſixty-two ſpecies.

ORDER VIII.

SCOLLOP-FOOTED.

Birds which have the bill ſtraight; and, the toes with ſcolloped membranes.

Genus.
1. Phalaropus.
2. Fulica

Genus.
3. Greba.

This order contains fourteen ſpecies.

ORDER IX.

WEB-FOOTED.

Birds which have the bill tending upwards; the noſtrils pervious; the feet palmated; and, the webs ſemi-lunated between each toe.

Genus.
1. Avoſetta.
2. Currira.
3. Flammingo.
4. Diomedea.
5. Alca.
6. Colymbus.
7. Mergus.
8. Rhyncops.
9. Sterna.

Genus.
10. Larus.
11. Procellaria.
12. Merganſer.
13. Anas.
14. Pinguin.
15. Pelecanus.
16. Phaeton.
17. Plotus.

This order contains one hundred and eighteen ſpecies.

CLASS VI.

QUADRUPEDS.

Animals with four feet only; and which live upon land.

ORDER I.

ALATI.

Quadrupeds that have their feet connected by thin broad membranes, which they uſe as birds do wings; and, the fore feet have extended toes.

I. THE BAT GENUS.

Species.
1. Veſpertilio Com.
2. Ves. Auritus.
3. Ves. Barbaſtellus.
4. Ves. Pipiſtrellus.
5. Ves. Serotinus.
6. Ves. Noctulus.
7. Ves. Equicalceus.
8. Ves. Cephalotes.
9. Ves. Kiriwonla.
10. Ves. N. Eboracen.

Species.
11. Ves. Barbatus.
12. Ves. Senegalen.
13. Ves. Moloſſus.
14. Ves. Peruvianus.
15. Ves. Spaſina.
16. Ves. Soricinus.
17. Ves. Spiculator.
18. Ves. Spectrum.
19. Ves. Vampyrus.
20. Ves. Graius.

ORDER II.

SOLIPEDES.

Quadrupeds which have hoofs conſiſting of one piece; and, which have ſix cutting teeth in each jaw.

I. THE HORSE GENUS.

Species.
1. Equus Arabicus.
2. Eq. Hiſpanicus.
3. Eq. Curſor.

Species.
4. Eq. Jugalis.
5. Eq. Venator.
6. Equulus.

2. THE ASS GENUS.

Species.
1. Aſinus Arabicus.
  α As. Perſicus.
  β As. Europaeus.

Mulus Aſinarius.
Mulus Equinus.

3. THE ZEBRA GENUS.

Species.
1. Zebra Africanus.

Species.
2. Zebra Indicus.

ORDER III.

BISULCI.

Quadrupeds with cloven hoofs.

DIVISION I.

Such as have eight cutting teeth in the lower jaw, and none in the upper.

1. THE OX GENUS.

Species.
1. Bos.
  α Sarluka.
  β Indicus.

Species.
2. Buffalo.
  α Bonaſſus.
3. Buf. Americanus.
4. Buf. Africanus.

2. THE SHEEP GENUS.

Species.
1. Ovis Communis.
  α Agreſtis.
  β Cretenſis.
  γ Anglica.

Species.
δ Polycerata.
ε Guineenſis.

Species.
ζ Arabica.
2. Barbatus.

3. THE GOAT GENUS.

Species.
1. Capra Com.
  α Domeſtica.
  β Angorenſis.
  γ Syrienſis.
  δ Africana.

Species.
  ε Judaenſis.
  ζ Capricorna.
2. Rupicapra.
3. Muſimon.

4. THE GIRAFFE GENUS.

Species 1. Camelopardus.

5. THE ANTELOPE GENUS.

Species.
1. Gazella Com.
  α Paſſana.
  β Bezoartica.
  γ Coudoua.
  δ Guiba.
  ε Grimmia.
  ζ Guineenſis.
  η Bengalenſis.
  θ Indica.
  ι Dama.
  κ Nagora, &c.

6. THE DEER GENUS.

Species.
1. Cervus Machlis.
2. Cer. Rangifer.
3. Cer. Platyceros.

Species.
4. Cer. Nobilis.
5. Cer. Virginianus.
6. Cer. Axis.

Species.
7. Cer. Porcinus.
8. Cer. Caprea.

Species.
9. Cer. Braſilenſis.
10. Cer. Guineenſis.

7. THE MUSK GENUS.

Species.
1. Moſchus Tibitus.
2. Mo. Braſilenſis.

Species.
3. Mo. Indicus.
4. Mo. Guineenſis.

DIVISION II.

Such as have ſix cutting teeth in the lower jaw, and none in the upper.

THE CAMEL GENUS.

Species.
1. Camelus Arabicus.
2. Cam. Bactrianus.

Species.
3. Cam. Llama.
4. Cam. Pacos.

DIVISION III.

The animals in this diviſion have cutting teeth in each jaw.

1. THE HOG GENUS.

Species.
1. Sus Fera.
2. Sus Aethiopicus.
3. Sus Mexicanus.

Species.
4. Sus Indicus.
5. Sus Rouſſa.

2. THE RHINOCEROS GENUS.

Species.
1. Rhinocer. Unicornis.

Species.
2. Rhin. Bicornis.

3. THE BEHEMOTH GENUS.

Species 1. Hippopotamus.

4. THE TAPIIR GENUS.

Species.	Species.
1. Tapiir.	2. Tapiir Sus.

DIVISION IV.

Such as have no cutting teeth; and have a proboſcis.

THE ELEPHANT GENUS.

There is now only one genus and ſpecies; but, from foſſil bones, there ſeem to have been more.

ORDER IV.

NODII.

Digitated quadrupeds, without teeth.

1. THE MANIS GENUS.

Species.	Species.
1. Phataginus.	2. Pha. Javenſis.

2. THE ANT EATER GENUS.

Species.	Species.
1. Myrmicophaga.	3. Myr. Didactyla.
2. Myr. Tamandua.	

ORDER V.

ATEMNODII.

Digitated quadrupeds, without cutting teeth.

I. THE SLOTH GENUS.

Species.
1. Tardigradus Tridac.

Species.
2. Tar. Didactylus.

2. THE ARMADILLO GENUS.

Species.
1. Daſypus Tricinctus.
2. Das. ſex cinctus.
3. Das. octo cinctus.

Species.
4. Das. novem cinct.
5. Das. duodecim cinct.
6. Das. octodecim cinct.

ORDER VI.

ACCUNODII.

Digitated quadrupeds without canine teeth.

I. THE CAVIA GENUS.

Species.
1. Cavia Cobaya.
2. Cav. Aperea.
3. Cav. Paca.
4. Cav. Aguti.

Species.
5. Cav. Akouchi.
6. Cav. Javaenſis.
7. Cav. Capenſis.
8. Cav. Moſcha.

2. THE HARE GENUS.

1. Lepus Com.
2. Lep. Alpinus.

Species.
3. Lep. Americanus.
4. Cuniculus.
5. Cu. Angorenſis.
6. Cu. Ruſſicus.

Species.
7. Cu. Braſilenſis.
8. Cu. Tolai.
9. Cu. Capenſis.

3. THE BEAVER GENUS.

Species.
1. Caſtor Com.
2. Cas. Zibethecus.

Species.
3. Cas. Ruſſicus.

4. THE PORCUPINE GENUS.

Species.
1. Hyſtrix Com.
2. Hys. Macroura.

Species.
3. Hys. Braſilenſis.
4. Hys. Canadenſis.

5. THE MARMOT GENUS.

Species.
1. Marmota.
2. Mar. Monax.
3. Mar. Sibillans.
4. Mar. Hameſter.
5. Mar. Souſlika.

Species.
6. Mar. Lemmar.
7. Mar. Citella.
8. Mar. Podoliana.
9. Mar. Circaſſiana.

6. THE SQUIRREL GENUS.

Species.
1. Sciurus Com.
2. Sc. Hudſonenſis.
3. Sc. Roekea.

Species.
4. Sc. Bombaia.
5. Sc. Griſeus.
6. Sc. Niger.

Species.
7. Sc. Coquallin.
8. Sc. Guzarat.
9. Sc. Braſilenſis.

Species.
10. Sc. Talmototli.
11. Sc. Palmiſta.
12. Sc. Boerndeſki.

7. THE DORMOUSE GENUS.

Species.
1. Glis Com.
2. Glis Lerotus.
3. Glis Muſcardinus.

Species.
4. Glis Javaenſis.
5. Glis Scythicus.

8. THE JERBOA GENUS.

Species.
1. Jerboa.
2. Jer. Siberenſis.

Species.
3. Jer. Linnaei.
4. Jer. Buffoni.

9. THE MOUSE GENUS.

Species.
1. Mus Com.
2. Mus Agreſtis.
3. Mus Acervator.

Species.
4. Mus Indicus.
5. Mus Brachiurus.
6. Mus Gregarius.

10. THE SHREW GENUS.

Species.
1. Sorex Com.
2. Sor. Araneus.
3. Sor. Aquaeus.
4. Sor. Minutus.

Species.
5. Sor. Javaenſis.
6. Sor. Braſilenſis.
7. Sor. Tucanus.

11. THE RAT GENUS.

Species.
1. Ratus Com.
2. Rat. Bandicotus.
3. Rat. Aquatilis.
4. Rat. Labrador.

Species.
5. Rat. Circaſſius.
6. Rat. Tamariſk.
7. Rat. Curaco.

There are many varieties of the three laſt genera.

12. THE MOLE GENUS.

Species.
1. Talpa Com.
2. Tal. Siberica.
3. Tal. Radiata.

Species.
4. Tal. Ferruginea.
5. Tal. Fuſca.
6. Tal. Rubra.

13. THE HEDGE-HOG GENUS.

Species.
1. Erinaceus Com.
2. Erin. Tendracus.

Species.
3. Erin. Guianus.

ORDER VII.

Digitated quadrupeds with canine, and with cutting teeth.

1. THE DOG GENUS.

Species.
1. Canis Paſtoralis.
    - α Pomeranenſis.
    - β Siberenſis.
    - γ Venaticus.
    - δ Braquenſis
    - ε Verucus.
    - ζ Aquaticus.
    - η Hiſpanicus.
    - θ Gredinus.
    - ι Pyramicus.

κ Melitaeus.
λ Hibernicus.
μ Graius.
ν Danicus.
ξ Moloſſus.
ο Britannicus.
π Dogillus.
ρ Roquetus.
σ Furcicus.

2. THE WOLF GENUS.

Species.
1 Lupus Com.
α Lup. Grecus.
β Lup. Capenſis.

3. THE FOX GENUS.

Species.
1. Vulpes Com.
2. Vul. Alopex.
3. Vul. Crucigera.
4. Vul. Niger.
5. Vul. Rubeus.

Species.
6. Vul. Areticus.
7. Vul. Carolinenſis.
8. Vul. Canadenſis.
9. Vul. Adive.
10. Vul. Thous.

4. THE HYAENA GENUS.

1. Hyaena Crocuta.
2. Hy. Maculata.

5. THE LION GENUS.

Species.
1. Leo.
2. Tigris.
3. Panthera.
4. Leopardus.
5. Guopardus.

Species.
6. Onca.
7. Pardalis.
8. Idaguara.
9. Couguara.
10. Ocelota.

Species.
11. Puma.
12. Idguereta.
13. Capenſis.

Species.
14. Margay.
15. Bengalenſis.
16. Manul.

6. THE CAT GENUS.

Species.
1. Felis Com.
  α Angorenſis.
  β Hiſpanicus.
  γ Coerulus.
  δ Catus Pardus.
  ε Maraputa.

7. THE LYNX GENUS.

Species.
1. Lynx.
2. Lynx Laurius.

Species.
3. Lynx Perſicus.

8. THE BEAR GENUS.

Species.
1. Urſus Niger.
2. Ur. Albus.

Species.
3. Gulo.
4. Racoon.

9. THE BADGER GENUS.

Species.
1. Meles Com.
  α Americanus.
  β Indianus.

10. THE OPOSSUM GENUS.

Species.
1. Opos. Murina.
2. Opos. Mexicana.

Species.
3. Opos. Philander.
4. Opos. Surinenſis.

11. THE WEASEL GENUS.

Species.
1. Muſtela Com.
2. Mu. Erminea.
3. Mu. Putorea.
4. Mu. Viverra.
5. Mu. Sarmatia.
6. Mu. Siberia.
7. Mu. Teretta.
8. Mu. Martes.
9. Mu. Abietum.
10. Mu. Sobella.
11. Mu. Piſcatorea.
12. Mu. Vanſira.
13. Mu. Pecanenſis.

Species.
14. Mu. Guineenſis.
15. Mu. Braſilenſis.
16. Ichneumon.
17. Ic. Suricata.
18. Ic. Coati.
19. Ic. Soſeſſans.
20. Ic. Striata.
21. Ic. Fiſcata.
22. Ic. Zorrilla.
23. Ic. Fizler.
24. Civetta.
25. Genetta.
26. Foſſana.

12. THE OTTER GENUS.

Species.
1. Lutra Com.
2. Lu. Minx.

Species.
3. Lu. Marina.

13. THE PROSIMIA GENUS.

Species.
1. Proſimia Lutra.
2. Pros. Barbata.

Species.
3. Pros. Flava.
4. Pros. Membranacea.

ORDER VIII.

SIMIAE

Are digitated quadrupeds, with feet reſembling hands.

DIVISION. I.

MONKIES.

Simiae which have tails more than eight inches long.

Genus.

1. Cynocephalus.
2. Silenus.
3. Ouanderou.
4. Sil. Albus.
5. Maculatus.
6. Cynomolgus.
7. Exquima.
8. Sabaea.
9. Lunala.
10. Cephas.
11. Talapoin.
12. Niger.
13. Egreta.
14. Senegalenſis.
15. Chinenſis.
16. Monichus.
17. Douca.
18. Aurantius.

Genus.

19. Nictitans.
20. Barbata.
21. Annulata.
22. Syrichta.
23. Braſilenſis.
24. Gumilla.
25. Teſdactilus.
26. Capucina.
27. Sim. Plorans.
28. Caitaia.
29. Fatuellus.
30. Antiguenſis.
31. Sim. Cagni.
32. Tamarin.
33. Striata.
34. Roſalia.
35. Pinchea.
36. Sagoina.

DIVISION II.

BABOONS.

Simiae which have tails that are not leſs than one inch, and more than four inches in length.

Genus.
1. Mandrilla.
2. Apodia.

Genus.
3. Maimona.

DIVISION III.

APES.

Simiae which have no tails.

Genus.
1. Maucauco.
2. Mantegara.
3. Barbarenſis.
4. Gibbon.

Genus.
  α Malacenſis.
  β Crivenſis.
5. Pithecus.
6. Orang Outang.

Of ſuppoſed varieties in this diviſion.

CLASS VII.

MAN.

Genus 1. Man.

Varieties in the human kind.

α Aſiaticus.
β Europeus.
γ Africanus.
δ Americanus.

There are very obvious differences between the human kind and all the animals, except the laſt diviſion of the ſimiae. But there is ſo great a reſemblance between them and man, that many perſons have thought they are of the ſame genus. With what reaſon, will appear from the following compariſon of their characters.

They differ in the proportions of the chin, and other parts of the face, and head; in the proportion of the arms to the body; in the proportions of the parts of the hands; in the proportions of the parts of the feet; in the femur; in the pelvis; in the fraenum; in the vertebrae; and, in the number of ribs.

In the time of geſtation, that of the one being nine months, and that of the other ſeven; in having no common progeny; in not having the ſame diſeaſes; and, in uttering no articulate ſounds, though the organs of ſpeech, and the formation of the brain are the ſame in both.

No animal can prepare meat and drink, like man; nor cover his body, nor make fires, according to the ſeaſon, or climate; nor diminiſh labour and increaſe conveniencies, by arts, and machines, which he varies according to his exigences; nor make inſtruments of war, and ſubjugation, by which he deſtroys, or domeſticates the fierceſt, and ſtrongeſt living creatures.

The other animals have not the ſame pleaſures of the imagination. They have no delight in viewing fine ſtatues, pictures, buildings, beautiful attire, graceful dancing, or magnificent ſcenes of nature; and, all men have the ſame ſcale in muſic.

Man is ſtill further diſtinguiſhed, and in a moſt remarkable manner, by intellectual powers; by a moral ſenſe; by religion; and, by the capacity which he has of improving, and debaſing the laſt eight of the above characters, through a long ſcale of perfection.

This compariſon is made upon the ſuppoſition that the accounts, which are the moſt favourable to the orang outang's being of the ſame genus with man, are well founded. We will have no doubt however of their being uncertain, when we conſider how difficult it is to learn the truth upon this ſubject; and how eaſy it was to have been well informed concerning the natives at the Cape of Good Hope, and in North America, and yet how falſe the anatomical accounts of both theſe people were; and which were believed by the learned till very lately. The very different accounts too, which have been given of the Jumar, and of Peter the wild man, will add ſtrength to this obſervation.

SECT. III.

OF OTHER SYSTEMS IN ZOOLOGY.

Of the ſtate of Zoology before the time of Ariſtotle; from that time to the fall of the Roman Empire; from that time to the revival of learning in Europe; and, from that era, to the preſen ttime.

SECT. IV.

THEORIES IN ZOOLOGY.

A comparative view of the three kingdoms of nature; of the characters which diſtinguiſh them; and, the laws by which their diſtinctions are preſerved.

ELECTRICITY.

SECT. I.

OF ELECTRICS AND NON-ELECTRICS.

PROP. I.

Every piece of matter is either an electric, or non-electric; or, which are ſynonymous terms, a non-conductor, or conductor.

To the firſt claſs, belong amber, glaſs, ſealing wax, ſulphur, roſin, baked wood, ſilk, feathers, wool, hair, paper, leather, &c.

To the ſecond claſs, belong metals, and ſemi-metals, water, flame, all fluids, excepting air and oils, animal bodies, common earth, &c.

Scholium. This propoſition is only true, when theſe bodies are rubbed, in the common manner. It will afterwards appear, that electrics, and non-electrics, are convertible into each other by a different manner of rubbing, and, by varying their temperature.

SECT. II.

OF ELECTRIC MATTER.

PROP. I.

An excited non-conductor, or electriſed conductor, when inſulated, is ſurrounded with a maſs of very ſubtile matter, which is the cauſe of the attraction, and repulſion of light bodies, when brought near it; and, the form of this matter is the ſame with that of the body it ſurrounds.

PROP. II.

The particles of electric matter, pervade the denſeſt conducting bodies, as well as places where there is little air; but, they do not pervade places where there is no air, or a perfect vacuum.

PROP. III.

Though electric matter is extremely ſubtile, yet it may be ſeen, if it runs off in a ſtream, or if it leaps from body to body, but not otherwiſe; and, it may be heard, ſmelt, felt, and taſted, if accumulated in large quantities.

Cor. Hence light is ſeen in a barometer at the top of the quickſilver when it falls; and, none is ſeen when it riſes; and, hence the effect of the military lantern.

PROP. IV.

Electric matter is not created by friction, but collected; being diffuſed through all bodies.

Cor. When we would accumulate electric matter, a communication ought to be made between the rubbers and the earth, or the walls of the houſe.

PROP. V.

Fire and electric matter ſubſiſt together in the ſame body. Water extinguiſhes fire, but ſerves to collect electric matter. Freezing is not retarded by electric matter, though accumulated in large quantities. A bar of metal may be heated at one end, while it is cold at the other; but, every part of it is electrified equally.

PROP. VI.

When electric matter ſtrikes through a body, if the body contains either phlogiſton, or pure fire, in a certain quantity, the body will be melted, or inflamed; and, though the proportions of the phlogiſton of the pure fire, and of the electric matter ſhould be varied, the ſame effects will follow.

PROP. VII.

By the electric ſhock, the calces of metals may be reſtored to their metalline ſtate; and, gold and ſilver may be calcined, ſome of the particles being converted into a tranſparent glaſs, and ſome tinged with various colours.

SECT. III.

OF THE ATTRACTION OF ELECTRIC MATTER.

PROP. I.

The particles of electric matter are attracted by other bodies, and with various degrees of force.

PROP. II.

Though electric matter paſſes through conducting bodies with great force, yet it brings none of their particles along with it; for it has the ſame acidulous phoſphorine taſte and ſmell, whatever is the body through which it paſſes.

Cor. Hence electric matter cannot be made a vehicle to perfumes, or medicines, in the way that ſome have aſſerted.

PROP. III.

If the ſurface of a body, on which electric matter is accumulated, is round, large, and ſmooth, it will continue electrified till the ſurrounding bodies attract the electric matter. If it has an edge, or angle, the electric matter will paſs off ſpeedily. If it has a ſharp point, or points, it is with difficulty that it can be electrified at all.

PROP. IV.

Pointed non-electrics ſerve to draw off, as well as to throw off, electric matter.

PROP. V.

When electric matter is drawn off by non-electric points, it is ſlowly, and without noiſe. When it is drawn off by round, or blunt bodies, it is ſuddenly, and with an exploſion, or ſnap.

COR. A great quantity of electric matter may be drawn off by a ſharp wire, without producing any ſenſible effect.

PROP. VI.

If electric matter paſſes through a body or bodies, which are good conductors, and the parts of which are in cloſe contact with each other, its motion is inſtantaneous, though the diſtance be ſeveral miles; but, if the bodies are not good conductors, or, if they are not in contact, but near each other, its velocity may be meaſured; and there is a diminution of its force.

PROP. VII.

An increaſe of ſurface, makes a body capable of receiving a greater quantity of electric matter; and, when all other circumſtances are equal, in proportion to its ſurface.

PROP. VIII.

Excited non-conductors, or electriſed conductors, retain their electric matter, till conductors that have leſs are brought near them, and then they are equally electrified; and, the quantity of the electric matter is equally divided among them, if all circumſtances are equal.

SECT. IV.

OF THE ELECTIVE ATTRACTION OF ELECTRIC MATTER.

PROP. I.

The following bodies attract, or conduct, electric matter according to the order in which they ſtand.

CLASS I. Iron, braſs, copper, ſilver, gold, lead.

CLASS II. Biſmuth, nickel, zinc, antimony arſenic, cobalt.

CLASS III. Metallic ores, ſemi-metallic ores.

CLASS IV. Charcoal, water, oil of vitriol, ſpirit of wine, animal bodies, moiſt vegetables, flame.

CLASS V. Common earth, common ſtone, glue, &c.

PROP II.

The following bodies are placed according to their non-attracting, or non-conducting qualities; the firſt in order being the moſt perfect non-conductors.

CLASS I. Diamond, ſapphire, carbuncle, opal, amethyſt, beryl, cryſtal, glaſs, and all vitrifications.

CLASS II. Venice talc, garnets, rubies, topazes, hyacinths.

Class iii. Amber, ſealing wax, baked wood, porcelain veſſels, ſilk, air, carnelians, reſins, ſulphur, ſalts, ſugar, pitch, gums, jett, oils, ether, marble.

Class iv. Down, wool, feathers, hair, parchment, horns, bones, whale-bone, ſhells.

Class v. Dry willow, mahogany, aſh, elm, oak, boxwood, ebony, &c.

Of the differences in the conducting, and non-conducting powers of the bodies in the above claſſes; according as they are more or leſs pure; and, according to other circumſtances.

PROP. III.

When electric matter paſſes through a body or bodies, and comes in its paſſage to a body or bodies, the conducting powers of which are different, it will run through that body which is the moſt perfect conductor, though its courſe ſhould be much longer. But, if the paſſage through the leſs perfect conductor is much ſhorter, it will go through the leſs perfect conductor entirely; or, divide itſelf between both, according to the quantity which is to paſs, or, the conducting power of the body. If it goes through a homogeneous body, or, through bodies that are equally good conductors, it will take the ſhorteſt paſſage.

Cor. i. A man may hold a piece of metal in his hand, and electric matter will paſs through the metal, without his receiving the leaſt ſhock; provided the quantity is not very great, nor the piece of metal very ſmall, compared to his hand.

Cor. 2. Hence, and from Prop. vi. Sect. iii. electric matter may be made to paſs through caſcades, lakes, or the ocean, though violently agitated; and, hence ſpeedy intelligence may be given to perſons at a great diſtance.

SECT. V.

OF THE REPULSION OF ELECTRIC MATTER.

PROP. I.

The particles of electric matter mutually, and ſtrongly repel each other.

Cor. 1. A ſmall jet of water when electrified, will ſpread out into many ſtreams; or, be divided, ſo as to be like drops of rain, or, like a fog.

PROP. II.

Water which only drops from a capillary tube, or, from a funnel, will run in a continued ſtream, or ſtreams, when electrified; and, the quantity that flows in ſtreams will be greater than that by drops in the ſame time. But, if the bore of the tube is larger than that of the largeſt capillary tube, the electric matter will not increaſe the quantity that runs in a given time.

SECT. VI.

OF THE THREE STATES OF ELECTRIC MATTER.

PROP I.

While a body is in the natural ſtate, if any light piece of conducting matter, whether inſulated or not, which is in the ſame ſtate, is brought near it, the light piece of matter will neither attract, nor be attracted. If the light piece of matter is in the plus ſtate, and inſulated, it will firſt be attracted, and then repelled. If in the minus ſtate, it will be attracted.

PROP. II.

If a body is in the poſitive ſtate, and the light piece of matter is in the natural ſtate, and inſulated, it will firſt be attracted, and then repelled. If the light piece of matter is in the plus ſtate, it will be repelled, provided the plus ſtates are equal; if unequal, it will firſt be attracted, and then repelled. If the light piece of matter is in the minus ſtate, it will be attracted, and then repelled, provided the quantity received can overcome its gravity, and put it into the natural ſtate.

PROP. III.

While a body is in the negative ſtate, and the light piece of matter is in the natural ſtate, it will be attracted. If the light piece of matter is in the plus ſtate, and inſulated, it will be attracted and afterwards repelled, provided the quantity given is more than ſufficient to put them both in the common ſtate, and to overcome its gravity. If it is in the minus ſtate, it will not be attracted, provided the minus ſtate of both is the ſame.

PROP. IV.

Smooth glaſs, rubbed in the common way, exhibits the poſitive ſtate; reſins, wax, and amber, the negative ſtate.

COR. Hence the terms, vitreous, and reſinous, ſtates; vitreous, and reſinous, electric matter.

PROP. V.

When an inſulated conductor is brought near an electrified body, it acquires, on the part neareſt to that body, a contrary ſtate; and, on the oppoſite part, the ſame ſtate with that of the electrified body. As the conductor is brought nearer, each of the ſtates will increaſe till brought within the ſtriking diſtance, when part of the electric matter will go off from the electrified body, and ſtriking upon the conductor will put it throughout in the ſame ſtate.

PROP. VI.

If an electric body is brought near an electrified body, the electric body will acquire the different ſtates, on different ſides. Theſe ſtates will increaſe as the diſtances decreaſe, till at laſt if ſome electric matter is communicated to the electric body, the electric body will not be throughout in one ſtate, but will often ſhew the different ſtates in different parts, and in alternate ſucceſſion.

PROP. VII.

The form of a pencil of electric matter paſſing from an electrified body in the dark, is like a cone, the baſe of which is to, or from, the body, according as it is in a poſitive, or negative ſtate.

SECT. VII.

OF THE LEYDEN PHIAL.

PROP. I.

At the ſame time that the wire, and the inſide of the phial are electrified plus, its outſide is electrified minus; and, in exact proportion.

PROP. II.

Both ſides of the phial cannot be reſtored to the ſame ſtate by inward communication, or contact of the parts. It muſt be done by a communication formed without, by ſome conducting body touching them both at the ſame time, or, touching them alternately. In the firſt caſe, both ſides are reſtored to the ſame ſtate, with the greateſt quickneſs; in the laſt caſe, by degrees.

Cor. A phial cannot be electrified that is foul, or moiſt on the outſide from the cork, or wire, all along to the coating.

PROP. III.

As no more electric matter can be thrown into the inſide of the phial, when all is driven from the outſide; ſo in a phial that is not electriſed, none can be thrown into the inſide, when none can eſcape from the outſide; and, in a phial that is electriſed, little can be drawn from the inſide, unleſs an equal quantity can, at the ſame time, get in at the outſide.

PROP. IV.

The ſhock to the nerves of the perſon who holds the phial, and touches the wire, is produced by the ſudden paſſing of the electric matter through his body, in its way from the inſide, to the outſide of the phial; or, by its acting upon the electric matter contained in his body.

PROP. V.

A phial may be electrified through the coating, as well as through the wire; and there will be the ſame exploſion, and ſhock to the nerves, if the electrified phial is held in one hand by the wire, and the coating is touched by the other, as when held by the coating, and touched by the wire. But, a phial electrified through the wire, will give the exploſion through the wire; and, one electrified through the coating, will give the exploſion through the coating; and in no other way.

PROP. VI.

A Leyden phial cannot be charged, if there is the leaſt crack, or fiſſure in the glaſs; or, if any part of it is not vitrified.

PROP. VII.

The whole force of the phial, and power of giving a ſhock, is in the glaſs itſelf; the conductors, in contact with the two ſurfaces, ſerving only to give to, or receive from, its ſeveral parts.

Cor. I. Hence, and from Prop. VII. Sect. III. it is not the abſolute quantity of non-conducting matter contained within the phial; but, all things being equal, the quantity of its ſurface that makes it capable of giving a greater ſhock.

PROP. VIII.

The properties of the Leyden phial may be given to a pane of glaſs, or to a plate of roſin, by coating it, and by accumulating electric matter upon one of its ſides, in the ſame manner as upon the ſide of the Leyden phial; and a maſs of dry air may be made to give a ſhock in like manner.

Cor. The phial will retain its charge a long time, if placed in dry air; or, if its wire is covered by a non-conducting body.

SECT. VIII.

OF ELECTRIC MACHINES.

Of the different methods of fitting up, and exciting glaſs globes, glaſs cylinders, glaſs plates, and baked wood.

Of prime-conductors, and the manner of inſulating bodies to moſt advantage.

Of jars, and batteries; and the beſt method of giving ſhocks, or of ſending great quantities of electric matter through bodies.

Of electrometers, made of a ſingle thread; of a thread and ball; of a thread, ball, and glaſs-ſemicircle; of a thread and two balls; of a quadrant and radius; of a diſcharger at different diſtances; and, of other electrometers.

Of the method of working an electropheros; which may be made of roſin, ſhell-lack, ſulphur, and Venice turpentine, melted together, in various proportions; or, of four parts of roſin, three of gum-lack, three of pitch, and two of Venice turpentine.

SECT. IX.

OF COHESION BY ELECTRIC MATTER.

PROP. I.

If two panes of glaſs, are applied to each other, if their external ſides are coated, and, if the one is electrified plus, and the other minus, there will be a ſtrong cohesion between them.

PROP. II.

White, or black pieces of ſilk, when excited, adhere to bodies with broad ſmooth ſurfaces, though ſuch bodies ſhould not be electrified.

PROP. III.

Two pieces of ſilk, one white, and another black, when excited, and brought together, will adhere together; and ſometimes with a force that will require many times their own weight to ſeparate them.

SECT. X.

OF THE EFFECT OF DIFFERENT ELECTRIC RUBBERS.

PROP. I.

Cloth, flannel, wool, ſilk, with, or without oil, and leather with, or without, chalk, greaſe, amalgam, &c. have very different effects upon the beſt electrics; ſo that according to the rubber, the body will appear to be an electric, or non-electric.

PROP. II.

The following non-electrics, may be excited like electrics, though not ſo ſtrongly, if inſulated, and rubbed gently againſt wool, or ſoft black ſilk.

Iron, ſilver, gold, tin, lead, copper, braſs.

Marble, pebbles, agate, gypſum, dried earth, unglazed earthen ware.

Pepper, cinnamon, cloves, mace, garlic, onions, carrots, turnips, potatoes, beans, peaſe, oranges, apples, cane, leaves of vegetables.

Ivory, bone, horn, ſhells of fiſhes, fowls, parchment, catgut, tallow, &c.

SECT. XI.

OF ELECTRICS AND NON-ELECTRICS, ACCORDING TO THEIR TEMPERATURE, OR TEXTURE.

PROP. I.

Amber, glaſs, wax, roſin, ſulphur, wood, air, &c. when made very hot, become conductors; and, by varying their temperature, they change from the conducting, to the non-conducting ſtate.

Cor. Hence an electric machine cannot be excited, and the Leyden phial will not give a ſhock, when they are much heated.

PROP. II.

If water is converted into ice, when at a few degrees below 32°, the ice will conduct; if, when at about 20° lower, it will not conduct. The conducting power of charcoal, is different according to the heat employed in making it; that which was made with the greateſt heat, being the moſt perfect conductor.

PROP. III.

The ſurfaces of new glaſs tubes often conduct electric matter, but, after ſome time, loſe that property. If they are made red hot, they recover it again, and loſe it as before.

Cor. 1. Hence electric machines become good by uſe, though they could not be excited at firſt.

Cor. 2. Though electric matter, commonly paſſes through the ſubſtance of conducting bodies; yet it ſometimes paſſes over their ſurfaces.

PROP. IV.

When freeſtone, and baked clay, are heated from 32° to 250°, they have conducting, and non-conducting fits, during the changes of that temperature.

PROP. V.

Some conductors, ſuch as ſtone, and brick, become non-conductors, when reduced to a fine dry powder; but, the minuteſt filings of metals, are always conductors.

PROP. VI.

Metallic calces, and the ruſt of metals, are non-conductors; and ſome animal, and vegetable ſolids, when reduced to aſhes.

SECT. XII.

OF CHANGING THE SURFACE OF THE ELECTRIC BODY, OR OF THE RUBBER.

PROP. I.

Vitreous bodies with ſmooth ſurfaces, when rubbed in the common manner, are in the plus ſtate; and vitreous bodies with rough ſurfaces, are in the minus ſtate.

PROP. II.

If the poliſh is taken off part of a glaſs tube, the plus and minus ſtates may be produced by the ſame ſtroke of the ſame rubber; and, if ſmoothneſs is reſtored to the unpoliſhed part by chalk and greaſe, the whole tube, will electrify plus, as if the poliſh had never been taken off it.

PROP. III.

White ſilk, when excited, electrifies plus; and black ſilk, electrifies minus.

PROP. IV.

A globe of ſealing wax, and a globe of glaſs with a ſmooth ſurface, communicating with each other, cannot be excited, if the rubbing of both, and if all other circumſtances are equal.

PROP. V.

Sealing wax may be electrified plus, by rubbing it with quickſilver, or tinfoil. A ſmooth glaſs tube, may be electrified minus, by rubbing it acroſs a cat's back, or with a rabbit's ſkin. Amber may be electrified plus, by a blaſt of air. Two pieces of plate-glaſs, may be excited by rubbing them gently againſt each other; and the one will be poſitive, the other negative. Almoſt all electrics will acquire either ſtate at pleaſure, by uſing proper rubbers; and the rubbers are always in a contrary ſtate to that of the body rubbed.

SECT. XIII.

OF ELECTRIFYING BODIES BY HEAT.

PROP. I.

The lapis tourmalenſis, may have each of its ſides, or both of them at once, made poſitive by friction; but it may be excited by heat, without any friction; and one of its ſides B, will be in the plus ſtate, while the other ſide D, will be in the minus. A ſmall degree of heat will ſometimes produce this appearance; but, it may eaſily be effected by plunging the tourmalin in hot water, and drying it afterwards.

PROP. II.

The tourmalin, not being electrical, will become ſo by cooling; but with this difference, that the ſide B will be in the negative ſtate, and the ſide D in the poſitive.

PROP. III.

If the tourmalin, in a non-excited ſtate, is heated equally, and ſuffered to cool without either of its ſides being touched, B will be poſitive, and D negative, the whole time of the increaſe, and decreaſe of its heat. But, if the heat is not equally diffuſed, as by the ſudden approach of a hot iron, the above appearances will vary.

PROP. IV.

If one piece is cut from the poſitive end of the tourmalin, and another from the negative end, the pieces will have the ſame properties which they had before they were cut off. But the oppoſite ſides of each piece will be plus and minus, according to the general property of the tourmalin; and the remaining part will have the ſame properties which it had when entire.

PROP. V.

The moſt of theſe qualities belong to the Braſil topaz, and to ſome other precious ſtones.

PROP. VI.

If a thin glaſs ball, has electric matter thrown into it, and is hermetically ſealed, it may be excited by heat alone; and air may be electrified plus, and minus, by changing its temperature.

PROP. VII.

Melted wax, poured into a veſſel of glaſs, or wood, is electrified negatively; and, the glaſs, or wood, is electrified poſitively.

PROP. VIII.

Chocolate becomes highly electrified by cooling in the tin-pans in which it is made. It ceaſes to be ſo, by handling; but, if melted again, it will be electrified as before, eſpecially if oil is added to it.

PROP. IX.

Sulphur is ſtrongly excited, if melted in an earthen veſſel, and left to cool upon conductors; but, it is not excited, if left to cool upon electrics. If it is melted in a glaſs veſſel, the ſulphur will be negative, and the glaſs poſitive, whether they are left to cool, upon electrics, or non-electrics. If it is poured into a veſſel of baked wood, it will become negative, and the wood poſitive; but, if into ſulphur, or rough glaſs, it will not be excited at all. If it is poured into a metal cup, and there left to cool, it will not be excited till they are ſeparated; and then it will be plus, and the cup will be minus.

SECT. XIV.

OF THE ELECTRIFYING QUALITIES OF SOME ANIMALS.

PROP. I.

The hair upon the heads of moſt infants, and upon ſome grown perſons, may be ſtrongly excited by friction. In the ſame manner, a quantity of electric matter may be produced from a cat's back, that will inflame ardent ſpirits. A ſimilar property, in ſome degree, belongs to ſome other animals.

PROP. II.

The torpedo, anguilla tremula, gymnotus, and ſome other fiſhes, have the power of giving ſhocks, which are communicated, and intercepted by the conductors, and non-conductors of electric matter.

SCHOL. It ſeems, that theſe animals can collect electric matter in the plus, and minus ſtates, upon the different ſides of their bodies, and then diſcharge it, like the Leyden phial, in order to deſtroy their prey, or to annoy their enemies; but, ſome things relating to this power require farther inveſtigation.

SECT. XV.

OF ELECTRIFYING MAGNETS AND IRON.

PROP. I.

Electric matter, and magnetic matter, may ſubſiſt together in the ſame body. The accumulation of electric matter, affects not the ſtrength of the magnet, in ſuſtaining weights, or in acting upon needles; allowance being made for the attractive, and repulſive power of electric matter, when acting upon light bodies, as in Sec. III.

PROP. II.

A ſtrong electric ſhock gives polarity to pieces of iron, of the ſize of a ſmall ſewing needle. If the iron, when ſtruck, lies eaſt and weſt, the end entered by the electric matter, will point north. If it lies north and ſouth, the end that lay towards the north will point north, at whatever end the electric matter entered. The polarity given is ſtrongeſt when the needle lies north and ſouth, and weakeſt when it lies eaſt and weſt.

PROP. III.

By a great electric ſhock, the poles of a magnetic needle are reverſed; and ſometimes the magnetic power is totally deſtroyed.

SECT. XVI.

OF ELECTRIFYING LIVING VEGETABLES, AND ANIMALS.

PROP. I.

The growth of ſmall vegetables is quickened, by electrifying them plus; and the contrary effect is produced, it is ſaid, by electrifying them minus.

PROP. II.

The pulſe of animals is commonly quickened, and their perſpiration increaſed, by electrifying them plus, for ſome time.

PROP. III.

Obſtructions are almoſt always removed, and other diſeaſes are ſometimes cured, by electric ſparks, and electric ſhocks; in giving which, the following rules ſhould be obſerved. The ſhocks ſhould be very ſmall at firſt, and ſhould never be ſo great as to give terror to the patient. In moſt caſes they ſhould be gentle, and frequent. They ſhould be given to palſied limbs, without paſſing through the vitals; and, when this rule is obſerved, they may be greatly increaſed. They ſhould be continued for a long time; and, ſhould be accompanied with proper medicines.

PROP. IV.

By great electric ſhocks, vegetables may be blighted, or killed; and, animals may be ſtruck blind, or diſabled in their limbs, or inſtantly deprived of life.

SECT. XVII.

OF ELECTRIC METEORS.

PROP. I.

It is aſcertained by undoubted evidence; that lightning ſometimes moves in ſtraight lines, and ſometimes in angular directions; that its colour is ſometimes white, and ſometimes red; that it is conducted by metals, water, and other non-electrics; and, is not conducted by glaſs, wax, and other electrics; that it ſcorches ſome bodies, burns others, and fuſes metals; that it diſſipates, or ſtrips off gilding, without hurting the paper, or painted wainſcot, to which it is fixed; that it makes holes in ſome bodies, and rends, and diſſipates others; that it gives polarity to iron, reverſes the poles of magnetic needles, or deſtroys the magnetic power entirely; that it blights, and kills vegetables; ſtrikes animals blind, diſables their limbs, or deprives them of life in a moment, bringing on a ſpeedy putrefaction; that it ſtrikes the higheſt, and moſt pointed bodies; and, is often accompanied with the noiſe called thunder.

Similar effects are produced by electric matter, as enumerated in the following propoſitions.

PROP. II.

Electric matter moves in the ſame manner, according as it goes through a ſhort ſpace, or among bodies irregularly diſpoſed, or through a conſiderable maſs of air; and its colour is like that of lightning.

PROP. III.

Lightning, and electric matter are conducted, and not conducted, by the ſame kinds of bodies, ſee Sect. IV.; and they inflame the ſame kinds of bodies, and fuſe metals, ſee Sect. II.

PROP. IV.

By a ſhock of electric matter, gold leaf may be diſſipated, or fuſed, without burning the paper, or painted boards, with which it is in contact. Holes may be ſtruck through bodies; wood may be ſhivered; glaſs may be broken; water, ſtone, lime, may be diſſipated; earth may be torn up; gun-powder fired.

PROP. V.

That the effects of electric matter upon iron, magnets, and vegetables, are the ſame as the effects of lightning upon them, appears from Sect. XV. and XVI.

PROP. VI.

Animals may be ſtruck blind by an electric ſhock, or diſabled in their limbs, or killed inſtantly; and the putrefaction of animal bodies, is haſtened by great ſhocks of electric matter.

PROP. VII.

Electric matter ſtrikes the higheſt, or moſt advanced bodies; and it makes a noiſe as loud as thunder, in proportion to its quantity, and the maſs of air which it agitates.

PROP. VIII.

By a wire joined to a boy's kite, or dragon, electric matter may be brought down from the clouds; and, in ſome ſtates of the weather, it may be collected even by a fiſhing rod, that has a wire fixed to it.

PROP. IX.

If a wire, or rod of metal, is ſupported by non-conductors, and raiſed higher than the neighbouring hills, trees, or edifices, it will be electrified by the clouds containing lightning, which come near it; and the Leyden phial may be charged, and every electrical experiment may be performed by it, in the ſame manner, as with a common electric machine.

PROP. X.

A rod of metal erected on buildings, and communicating through non-conductors, or leſs perfect conductors, with the moiſt earth, will either prevent a ſtroke of lightning altogether, or conduct it into the earth, ſo as that the building will receive no harm. The rod will beſt anſwer this purpoſe, if it is pointed, and pyramidical, and if care is taken to keep it from ruſt.

PROP. XI.

If a rod of metal with a ſharp point, and a few feet in length, is fixed on the maſt-head of a ſhip, which has no ſpindle, with a ſlack chain going from its lower end, by the ſhrouds into the ſea, it will ſave the ſhip from being ſtruck by lightning.

Cautions to be obſerved in uſing electrical kites; in erecting thunder rods; and, in making places ſecure in fields, and houſes, againſt the deſtructive effects of lightning.

Of the luminous appearances, deſcribed by the ancients, under the name of Prodigies, Caſtor and Pollux, &c.; and, by the moderns, under the name of Lambent Fire, Commozants, Corpoſants, St. Helmo's Fire, &c.

PROP. XII.

The prodigies that have been ſeen on the ſpears and helmets of ſoldiers; the commozants on the maſts and irons of ſhips; and, the lambent fire on the tops of ſteeples, may be imitated by electric matter.

PROP. XIII.

There ſeem to be two ſpecies of ignis fatuus; one which is inflammable air burning ſlowly on marſhy ground; and another, which is ſmall quantities of electric matter, moving from place to place; and which, it is ſaid, affects an electrometer if cautiouſly brought near it.

PROP. XIV.

When a maſs of wet, irregular earth is electrified, and a ſtream of air is made to paſs over it, the appearances reſemble the ſecond ſpecies of the ignis fatuus.

Of the meteors called northern lights, ſky-ſtreamers, aurora borealis, and auſtralis.

PROP. XV.

During a bright, and ſtrong aurora borealis, a noiſe is heard in high latitudes; and the magnetic needle rambles from its uſual poſition.

If electric matter is made to paſs through a rare atmoſphere, it will dart from place to place, with the ſame appearances. A ſimilar noiſe, in a ſmall degree, may be produced by the ruſhing of electric matter; and a ſimilar rambling may be given by it, to a magnetic needle, or to a needle of the ſame conſtruction that is not magnetical.

Of the bolis, or ſmall meteors, commonly called ſhot or ſhooting ſtars.

PROP. XVI.

If electric matter is made to paſs through a rare atmoſphere, in which moiſture is irregularly placed, there are appearances which reſemble the bolis.

Of the large meteors called fire-balls, which are ſometimes ſeen in the atmoſphere, and which move with aſtoniſhing velocity over many countries.

PROP. XVII.

When a mixture of inflammable air, and turpentine is laid in a long, thin ſtratum, and fired, in a dark night, it has the appearance of a moving globular maſs of fire, if viewed at the diſtance of four or five hundred feet. When electric matter is made to paſs through a long tube of glaſs, the air in which is about 150 times rarer than the atmoſphere, it has a globular appearance in its motion, to thoſe who view it at the diſtance of about fifty feet. It is ſaid that magnetic needles, and electrometers, are affected during the paſſage of theſe meteors; and, that ſome perſons, who have peculiar ſenſations during the time of lightning, have the ſame when theſe meteors are ſeen.

SECT. XVIII.

THEORIES IN ELECTRICITY.

An account of the different theories that have been maintained on this ſubject.

A review of the experiments by which the above propoſitions are proved; together with other experiments, upon which a theory of the electrical phenomena is founded.

MAGNETISM.

SECT. I.

OF MAGNETS, AND THEIR USES.

Of the hiſtory of the magnet; and the great effects which it has produced in human affairs, and in the ſciences.

SECT. II.

OF THE ATTRACTIVE POWER OF MAGNETS.

PROP. I.

Magnets attract iron, and no other body, or bodies whatever, unleſs they have a mixture of iron.

PROP. II.

The action, and re-action, of the magnet and iron are mutual and equal.

PROP. III.

There are two parts in a magnet called its ſouth and north poles, which attract with greater force than its other parts

PROP. IV.

If two magnets are brought near each other, and have a free motion, they will mutually attract each other, when their poles are of a contrary denomination. But, if their magnetic powers are very unequal, and, if they are brought very near each other, they will attract though of the ſame denomination.

PROP. V.

The attractive power of magnets decreaſes, as the ſquares of the diſtances increaſe; but this law is ſubject to variations from different cauſes.

PROP. VI.

The attraction of the magnet is not hindered, nor increaſed, by the interpoſition of any body whatever; excepting ſuch as are magnetical, or ſuch as are capable of being made ſo.

SECT. III.

OF THE REPULSIVE POWER OF MAGNETS.

PROP. I.

If two magnets are brought near each other, and have a free motion, they will mutually repel each other, when their poles are of the ſame denomination. But they will attract, if their magnetic powers are very unequal, and if they are brought very near each other.

PROP. II.

The repulſive power of the magnet is ſubject to the ſame law with the attractive; and is equally unaffected by the interpoſition of every body, excepting magnets, and iron. Sect. II. Prop. V. VI.

SECT. IV.

OF THE COMMUNICATIVE POWER OF MAGNETS.

PROP. I.

A magnet will communicate its virtue to a piece of iron, that is rubbed upon its poles, or brought near them; and without any diminution of its own virtue, provided the iron is ſmall, when compared to the magnet.

PROP. II.

Iron acquires, and loſes, the magnetic virtue much ſooner than ſteel.

SECT. V.

OF THE DIRECTIVE POWER OF MAGNETS.

PROP. I.

When a magnet is floated, or ſuſpended, ſo as to have a free, and eaſy motion, one of its poles will always turn towards the north, and the other towards the ſouth.

PROP. II.

If the magnetic virtue is communicated to a ſmall piece of iron, that is floated, or hung by a thread, or moveable on a prop, it will have a directive power like a magnet; and it is called a magnetic needle.

Cor. From the above properties of the magnet, it is eaſy to underſtand many tricks, or contrivances, which excite wonder.

SECT. VI.

OF THE MAGNETIC COMPASS.

Of the various ways in which the magnetic compaſs was formerly made for ſea, and land.

Of the points of the compaſs, or rhumbs.

Of the conſtruction, and uſe of the common mariners compaſs.

Of the beſt needle, cap, prop, and caſe, for the mariners compaſs; and the beſt manner of fitting it up.

SECT. VII.

OF THE DECLINATION OF THE NEEDLE.

PROP. I.

At Paris, the declination, or variation, of the magnetic needle, at a medium, was A. D. 1541; 7° Eaſt. A. D. 1550; 8°, 0′, E. A. D. 1580; 11°, 30′ E. A. D. 1610; 8°, 0′ E. A. D. 1640; 3°, 0′ E. A. D. 1664; 0°, 40′ E. A. D. 1666; 0°, 0′.

A. D. 1670; 1°, 30′ Weſt. A. D. 1680; 2°, 40′ W. A. D. 1686; 4°, 30′ W. A. D. 1692; 5°, 50′ W. A. D. 1700; 8°, 12′ W. A. D. 1710; 10°, 50′ W. A. D. 1720; 13°, 0′ W. A. D. 1726; 13°, 45′ W. A. D. 1728; 14°, 0′ W.; from which time, to A. D. 1771, it moved to 19°, 45′ W.; and from A. D. 1771, at a ſlower rate weſt

PROP. II.

At London, the mean variation A. D. 1576, was 11°, 15′ eaſt. A D. 1612; 6°, 10′ E. A. D. 1622; 6°, 0′ E. A. D. 1634; 4°, 5′ E. A. D. 1657; 0°, 0′.

A. D. 1665; 1°, 22′ weſt. A. D. 1672; 2°, 30′ W. A. D. 1683; 4°, 30′ W. A. D. 1692; 6°, 0′ W. A. D. 1700; 8°, 0′ W. A. D. 1730; 10°, 15′

W. A. D. 1744; 14°, 15′ W. A. D. 1756; 15°, 15′ W. A. D. 1759; 17° W.

The mean of the annual variation for ſeveral years paſt in London has been about 10′ W. A. D. 1774; it was 21°, 16′ W. A. D. 1775; 21°, 43′ W. A. D. 1776; 21°, 47′ W. and A. D. 1778; 22°, 20′, 15″; but making an allowance for the magnetic power in the building, it was 21°, 55′ 30″.

PROP. III.

At Glaſgow, the mean variation A. D. 1775, was 24°, 21′ W. A. D. 1776; 24°, 30′ W. and A. D. 1778; 24°, 32′ W.

At Stromneſs, A. D. 1774; lat. 58°, 59′ N. long. 3°, 30′, it was 24° W.

In Hudſon's Straits, A. D. 1774; lat. 62°, 3′ N. and long. 69° W; it was 43° W. A. D. 1774; lat. 62°, 25′ N. and long. 71°, 30′ W. it was 44° W. A. D. 1773; lat. 79°, 50′ N. and long. 10°, 2′, 30″ E. it was 20°, 38′ W. A. D. 1774; lat. 56°, 53′ N. and long. 85°, 22′ W. it was 24° W. A. D. 1774; lat. 51°, 20′ N. and long. 82°, 30′ W. it was 17° W.

A. D. 1786; lat. 72°, 20′ N. long. 4°, 56′ W. the variation was 2°, 40′ W.; and in lat. 81°, 30′ N. long. 9°, 16′ E. it was 2°, 30′ W.

PROP. IV.

Near the equator, in long. 40° E. the higheſt variation from A. D. 1700, to A. D. 1756, was 17°, 15′ W. and the leaſt 16°, 30′ W. In lat. 15° N. and long. 60° W. the variation was conſtantly 5° E. In lat. 10° South, and long. 60° E. it decreaſed from

17° W. to 7°, 15′ W. In lat. 10° S. and long. 5° W. it increaſed from 2°, 15′, to 12°, 45′ W. In lat. 15° N. and long. 20° W. it increaſed from 1° W. to 9° W. In the Indian ſeas, the irregularities were greater, for A. D. 1700, the weſt variations decreaſed regularly from long. 50° E. to long. 100° E.: but A. D. 1756, it decreaſed ſo faſt, that there was eaſt variation in long. 80°, 85°, and 90° E.; and yet, in long. 95°, and 100° E. there was weſt variation.

PROP. V.

In the ſouthern hemiſphere, A. D. 1772, lat. 20°, 28′ S. and long. 22°, 7′ W. the variation was 3°, 16′ W. In lat. 25°, 12′ S. and long. 23°, 31′ W. it was 1°, 11′ W. In lat. 40°, 20′ S. and long. 16°, 27′ W. it was 19°, 55′ W.

A. D. 1774, in lat. 15°, 6′ S. and long. 241°, 0′ E. it was 2°, 31′, 30″ E. In lat. 10°, 30′ S. and long. 220°, 8′ E. it was 5°, 28′, 30″ E. In lat 20°, 1′, 30″ S. and long. 184°, 40′ E. it was 11°, 8′, 15″ E. In lat 20°, 52′ S. and long. 166°, 8′ E. it was 10°, 12′ E.

A. D. 1775, in lat. 58°, 17′ S. and long. 348°, 16′ E. it was 0°, 16′ W. In lat. 2°, 24′ N. and long. 32°, 12′ W. it was 0°, 14′, 45″ W. In lat. 50°, 6′, 30″ N. and long. 4°, 0′ W. it was 19°, 28′ W.

Of the variations collected by Halley, and by Dodſon and Mountaine: and of variation charts, and books.

Of the variation compaſs; and the beſt manner of fitting it up.

Of the azimuth compaſs, and its uſe.

Of the importance to philoſophy, and to navigation, of obſerving the variations in different parts of the earth.

SECT. VIII.

OF THE INCLINATION OF THE NEEDLE.

PROP. I.

At London, the inclination, or the dip, of the magnetic needle A. D. 1576, was 71°, 50′. A. D. 1653; 72°, 45′. A. D. 1676; 73°, 30′. A. D. 1720; 75°, 10′. A. D. 1723; about 75°.

PROP. II.

The mean dip of the needle at London, A. D. 1775, 1776, was 72°, 30′. At Glaſgow, A. D. 1775, 1776; 75°, 30′. At Stromneſs, A. D. 1774; 75°, 45′; and, in Hudſon's Straits, 82°, 40′.

A. D. 1773, in lat. 52°, 17′ N. and long. 1°, 45′, 15″ E. it was 73°, 22′. In lat. 60°, 17′ N. and long. 2°, 42′, 30″ E. it was 73°, 30′. In lat. 70°, 45′ N. and long. about 0°, 22′, E. it was 77°, 52′. In lat. 74°, 5′ N. and long. 9°, 43′ E. it was 79°, 30′. In lat. 77°, 59′ N. and long. 11°, 4′, 30″ E. it was 80°, 26′. In lat. 78°, 36′ N. and long. about 10°, 17′, 30″ E. it was 80°, 45′. In lat. 80°, 29′ N. and long. about 11° E. it was 81°, 52″.

A. D. 1775, the dip at Albany Fort, lat. 52°, 24′ N. and long. 83°, 30′ W. was 79°, 17′, 7″. In lat. 56°, 53′ N. and long. 85°, 22′ W. it was 82°, 25′.

PROP. III.

In the ſouthern hemiſphere A. D. 1773, in lat.

38°, 21′, 30″ s. and long. 178°, 83′, 45″ E. it was 62°, 25′, 40″. In lat. 45°, 47′, 56″ s. and long. 166°, 2′, 46″ E. it was 70°, 4′, 5″.

A. D. 1774, in lat. 55°, 21′, 57″ s. and long. 289°, 57′, 9″ E. it was 66°, 5′, 2″.

A. D. 1775, in lat. 15°, 55′ s. and long. 5°, 49′ W. the mean of the dip was 11°, 20′, 45″.

PROP. IV.

The inclination is different in the ſame latitude and longitude, according to the length of the needle, its weight, its magnetic power, and the manner in which it is ſuſpended.

Cor. Though therefore there are tables of the inclination of the needle in a great variety of latitudes, and longitudes; yet there are only a few of them which are correct; becauſe no accurate account is given of the needles that were uſed, when the obſervations were made.

Of various contrivances to render the dipping needle more perfect, by friction wheels, circular motions, and ſpirit levels.

Of dipping, and variation, needles, ſuſpended in cloſe glaſs veſſels full of alcohol.

Of tables and charts of the dip of the needle in different parts of the earth; and the importance to philoſophy and navigation if ſuch tables were made perfect.

The lat. of Greenwich is 51°, 28′, 40″ N. and the long. 0°, 0′, 0″. The lat. of Paris is 48°, 50′ 14″ N. and the long. 2°, 20′, E. The lat. of Glaſgow is 55°, 51′, 36″ N. and the long. 4°, 24′, W.

SECT. IX.

OF THE DAILY VARIATION OF THE NEEDLE.

PROP. I.

From about eight or nine o'clock in the morning, every day, a good variation needle moves weſtward, till about two or three o'clock afternoon, when it becomes ſtationary for ſome time; after which, it gradually comes back to its former ſituation, or near it, by the next morning.

PROP. II.

This daily variation, which is commonly from 6′ to 14′, is greater in ſummer than in winter; and it is moſt remarkable in ſudden changes of the temperature of the weather, or of the place where the needle is kept.

PROP. III.

There is a daily variation in a fine dipping needle, which is ſimilar to that of the horizontal needle; but its daily variation, ſeems not to be ſo great, as that of the horizontal needle.

SECT. X.

OF ARTIFICIAL MAGNETS.

PROP. I.

A bar of iron will acquire the properties of the magnet, by placing it for ſome time in a ſituation perpendicular to the ſurface of the earth; and, in northern countries, the end next the earth is the north pole.

PROP. II.

The magnetic power may be given to a piece of iron, by hammering it, when cold, in the magnetic line; or, by plunging it in water, when red hot, in the ſame, or in a vertical poſition.

PROP. III.

By rubbing pieces of iron againſt each other, they become magnetical; or by breaking a piece of iron, by bending it often in different directions.

Cor. 1. Hence it is that ſmall ſewing needles are commonly magnetical; and, as they will ſwim in water by their repulſive power, they may be uſed, in time of need, as a mariner's compaſs; or, if they have loſt their poliſh, a bit of wood may be added to make them float.

Cor. 2. Braſs, zinc, and other bodies which commonly contain a ſmall quantity of iron, may acquire ſome magnetic virtue, by hammering, and rubbing.

PROP. IV.

Small magnets may be made, by ſhocks of electric matter. See Electricity, Sect. xv. Prop. 11.

PROP. V.

If ſeveral plates of ſteel are touched by a ſtrong magnet, if they are put together, ſouth pole to ſouth pole, with iron interpoſed, and properly armed, they will make a good artificial magnet.

PROP. VI.

Artificial magnets made, according to the methods of Savary, Knight, Michel, and Canton.

PROP. VII.

By theſe methods, magnets may be made at a ſmall expence, which are much ſuperior to any that are natural.

SECT. XI.

OF DIMINISHING THE VIRTUE OF MAGNETS.

PROP. I.

If a piece of iron is not kept in contact with a magnet, or near its poles, the ſtrength of the magnet will be diminiſhed.

PROP. II.

A magnet is diminiſhed in power, by not being kept, or depoſited, in ſuch a manner as that its poles are in the magnetic line, or line of variation; the pole, commonly called the north pole, being placed towards the north pole of the earth in the northern hemiſphere; and, the pole commonly called the ſouth pole, being placed towards the ſouth pole of the earth, in the ſouthern hemiſphere.

Of the contrary manner of naming the poles of a magnet, in conſequence of the earth's being conſidered as a great magnet.

PROP. III.

The ſtrength of a magnet may be diminiſhed, by laying it near a ſtronger one; and, if magnets of equal ſtrength are placed near each other, their virtue will be diminiſhed; unleſs the poles of the ſame denomination are placed alternately, or unleſs a piece of iron is interpoſed.

PROP. IV.

Though the power of a magnet is not diminiſhed by communicating its virtue to a ſmall piece of iron; yet it may be diminiſhed greatly by communicating its virtue to a piece of iron that is large, compared to the ſize, or ſtrength of the magnet.

PROP. V.

Heat diminiſhes the ſtrength of a magnet; and if it is much heated in the fire, it will loſe its virtue altogether.

PROP. VI.

A ſmart ſtroke will ſometimes change the poles of a magnet, and ſometimes deſtroy the magnetic power entirely. Similar effects may be produced by a great ſhock of electric matter.

SECT. XII.

OF INCREASING THE VIRTUE OF MAGNETS.

PROP. I.

A natural magnet is ſometimes ſo formed, that it may be divided by a Saw, in ſuch a manner as that two, or more magnets, may be made out of it; and one, or two of them, may have a ſtronger virtue than the ſingle ſtone had, before it was divided.

PROP. II.

By arming a magnet, it will give a ſtronger touch, and ſuſtain a greater weight.

PROP. III.

The virtue of a magnet may be improved by placing it near ſtronger magnets, in a certain manner, ſee Sect. XIII. Prop. IV.; or by placing many bars, or large pieces of iron, at its poles; or, if it is an artificial magnet, by letting it ly for a long time in the magnetic line, immerſed in oil of lintſeed.

SECT. XIII.

OF CHANGING THE POLES OF MAGNETS.

PROP. I.

If a ſmall flat magnet B, having its poles at each end, is placed lengthwiſe between two larger magnets C and D, the ſouth poles of which are oppoſed to each other; and, if the north poles of two ſmaller magnets E and F are applied to the middle of B, then both the ends of B will have ſouth poles, and its middle will be one continued north pole.

PROP. II.

The oppoſite ends of the magnet B, which are now ſouth poles, may be made both north poles, and the two ſides, ſouth poles, by an operation ſimilar to the laſt.

PROP. III.

If B is placed ſo as that the oppoſite halves of its two flat ſurfaces are in contact with the contrary poles of C and D, when placed in the ſame ſtraight line; and, if after remaining ſo for ſome time, the oppoſite halves are placed in the ſame manner, but in a contrary direction, then the one half of the ſurfaces of B will be a north pole, and the other half a ſouth pole; ſo that the north pole of the one ſurface will be oppoſite to the ſouth pole of the other.

PROP. IV.

If B is placed between C and D, ſo as to give it a ſtrong and regular polarity at the two ends; and, if its whole ſurface, except the poles, is touched with the pole of D or of E, but in a direction quite contrary to the firſt polarity; then the north pole of B will be ſurrounded with a ſouth pole, and its ſouth pole will be ſurrounded with a north pole; ſo that the edges of each ſurface will have a pole of a different denomination from that which occupies the middle.

SECT. XIV.

OF THE CAUSE OF THE MAGNETIC VIRTUE.

PROP. I.

The magnetic power, or virtue, ſeems to move in a ſtream from one pole of a magnet to the other, internally; and to be then carried back in curve lines externally, till it arrives at the pole to be again admitted.

PROP. II.

The immediate cauſe, why two or more magnetical bodies attract each other, ſeems to be the flux of the ſame ſtream of magnetic matter through them.

PROP. III.

The immediate cauſe of magnetic repulſion, ſeems to be the conflux, and accumulation of the magnetic matter.

SECT. XV.

THEORIES IN MAGNETISM.

Of the hypotheſes which have been formed, in order to explain the phenomena of the magnet.

A theory of the attractive, repulſive, communicative, and directive power of the magnet; of the declination, and inclination of the needle, diurnal and annual; of artificial magnets; and, of other facts which belong to Magnetiſm.

GRAVITATION.

SECT. I.

OF GRAVITY UPON, OR NEAR, THE SURFACE OF THE EARTH.

PROP. I.

When a body reſts upon a body, or bodies, it acts with a force that is called gravity, preſſure, or weight. And, when the body, or bodies are removed, the power of gravity gives motion to the body that was at reſt, towards the earth, or in the direction which the perſon who makes the experiment calls downwards; in whatever part of the earth he is placed.

PROP. II.

All bodies, whether called hard, or ſoft, or heavy, or light, are ſubject to the power of gravity, and at all times.

Cor. Bodies, which are moved by gravity alone, have a motion that is equably accelerated.

PROP. III.

The preſſure, and motion of all bodies acted upon by gravity alone, is in lines perpendicular to the horizon.

Cor. Hence the uſe of the plummet in drawing lines perpendicular, or parallel, to the horizon.

Though ſuch perpendiculars are not exactly parallel, ſee Prop. VII. yet if drawn in a great plane, and near the ſame place, the errors are ſo ſmall that human art cannot meaſure them.

PROP. IV.

Whatever are the forms, or the quantities of matter in bodies, the motions given to them by gravity alone, are equally ſwift; provided they fall from the ſame height, and meet with no reſiſtance.

Cor. 1. The weight of bodies is according to their quantities of matter; and not according to their forms, or bulks.

Cor. 2. The preſſure of bodies is according to the ſame law; but the effects of preſſure upon the reſiſting body, or bodies, may be different according to the baſes of the preſſing bodies, or the coheſions, or denſities of the reſiſting bodies.

PROP. V.

When bodies fall through the ſame reſiſting medium, their retardations are proportional to their quantities of matter, all other circumſtances being equal.

PROP. VI.

This is the power of gravity in Britain, upon a ball of metal that falls perpendicularly towards the earth, with the correſponding times, and ſpaces nearly.

Times of falling.	Spaces paſſed over.
One fourth, of a Second.	1 Foot.
Two fourths,	4
Three fourths,	9
Four fourths,	16
Five fourths,	25
Six fourths,	36

Cor. 1. The ſpaces therefore which are paſſed over by a falling body, are as the ſquares of the times of its motion; and, if the times of falling are increaſed, the ſpaces paſſed over will be nearly as in the following table.

Seconds of time.	Feet in the fall.	Seconds of time.	Feet in the fall.
1	16	15	3600
2	64	20	6400
3	144	25	10000
4	256	30	14400
5	400	35	19600
6	576	40	25600
7	784	45	32400
8	1024	50	40000
9	1296	55	48400
10	1600	60	57600

Cor. 2. Taking equal parts of time, the ſpaces deſcribed by a falling body, in each ſucceſſive part of time are as the numbers 1, 3, 5, 7, 9, 11, &c.; and a body moving uniformly with the velocity acquired by falling through any ſpace, will deſcribe twice that ſpace in the time of its fall.

Cor. 3. If a body is thrown perpendicularly upwards, with the velocity which it acquired by falling in a given time, it will, in the ſame time, arrive at the ſame height, and loſe all its motion; and, when bodies are thrown perpendicularly upwards, the heights of their aſcent are as the ſquares of their firſt velocities, or as the ſquares of the times of thei aſcending.

Cor. 4. The velocities, and conſequently the impulſes of a falling body againſt a firm obſtacle, are as the ſquare roots of the ſpaces through which they paſs.

PROP. VII.

That the figure of the earth is globular is proved by the following phenomena:

The riſing, and ſetting of the ſtars is accelerated to a traveller who goes eaſt, and retarded to one who goes weſt; but, if he goes from ſouth to north, the north pole is elevated about one degree for every ſixty-nine miles and a half; and the contrary, if he goes ſouth.

When the ſhadow of the earth falls upon the moon it is always circular.

To the people in a ſhip which approaches a tall object, the higher parts of it come firſt in view; and, when ſhe recedes from it, the lower parts are the firſt that diſappear.

A ſhip that continues to ſail in one direction ſurrounds the earth.

If one ſhip ſails round the earth by going eaſt, while another ſails round it by going weſt, when they meet at the place they left, there will be a difference of two days in the computation of time, by the people in the different ſhips.

Perpendiculars to the horizon made by plummets, at conſiderable diſtances from each other, are found not to be exactly parallel, but to tend towards a centre.

When the ſun ſets to a man on the ſurface of the earth, if he is ſuddenly raiſed to different heights in the air, he will ſee it ſet again, and again.

Cor. Since the length of 1°, or one part of 360°, meaſured upon the ſurface of the earth, is about ſixty-nine Engliſh miles and a half, the circumference of the earth, if a true globe, is 25,020 miles, in round numbers; or, more exactly, if the length of 1° on the ſurface of the earth is 25 French leagues, its whole circumference, if a true globe, is 9,000 leagues; each league containing 2,283 toiſes, 830 of which make an Engliſh mile, or 5,280 ſtatute feet.

PROP. VIII.

By meaſuring a degree of the earth at different latitudes, it was found that the earth is an oblate ſpheroid; the axis being to the diameter of the equator, as 229 to 230; that is, the ſemi-axis is about ſeventeen miles leſs than the ſemi-diameter of the equator.

Cor. If one diameter of the earth is 6,562,024 fathoms, or 2,874 leagues, and three fourths; and, if the other diameter is 6,525,376 fathoms, or 2,858 leagues and two fifths; then the whole bulk of the earth is 12,366,044,000 cubic leagues; its whole ſurface 25,858,089 ſquare leagues: and, if we ſuppoſe its mean denſity to be equal to that of common clay, a cubic foot of which weighs about 140 libs.; then the weight of a cubic fathom of the earth is 30,240 libs.; the weight of a cubic league of the earth is 359,775,200,000,000 libs.;

and the weight of the whole terraqueous globe is 4,448,994,000,000,000,000,000,000 libs.

PROP. IX.

In different latitudes of the earth, the power of gravity is different; and, by calculations founded on experiments, is, in proportional numbers, as follows:

Gravity.	Lat. North.	Places.
100000	48° 50′	Paris.
100018	51 28	London.
100126	64 35	Archangel.
100137	66 48	Pello.
99929	41 44	Rome.
99925	30 2	Cairo.
99732	18 27	St. Domingo.
99744	18 0	Jamaica.
99533	14 44	Martinico.
99533	4 56	Cayenne.
	Lat. South.	
99631	0° 2′	P. Palmar.
99605	0 9	Rhiobambe.
99802	0 14	S. Sea Coaſt.
99643	0 25	Quito.
99906	16 0	St. Helena.
100036	34 24	C. Good Hope.

See Mechanics, Part vi. Sect. iv. and v.

PROP. X.

The difference of the power of gravity at ſmall diſtances from the level of the ſea, cannot be perceived by the preſſure of a body, or by the time in which it falls. For if the radius of the earth is 4000 miles;

at the top of a mountain, one mile in perpendicular height, the diſtance from the centre of the earth will be 4001 miles; and, therefore, the power of gravity at the level of the ſea, and at the top of the mountain, will be as 16,000,000 to 16,008,001; or, as 16,000 to 16,008. But, by experiments made with pendulums at the level of the ſea, and at different altitudes from it, upon the immenſe mountains in South America, it was found that the power of gravity decreaſes as we recede from the centre of the earth, and nearly in the inverſe duplicate ratio of the diſtances.

Cor. If a body, on the ſurface of the earth, or at one ſemi-diameter from the centre, weighs 3,600 libs. it will, at the diſtance of 2, 3, 4, 5, 6, ſemi-diameters weigh 900,400,225,144,100 libs.; ſuppoſing the power of gravity extends beyond the earth, and decreaſes according to the above law.

PROP. XI.

The power of gravity in mountains, acts laterally upon plummets that are near them.

By the attraction of the mountain Chimboraço in Peru, a plummet was drawn from the true vertical line, ſo as to make an angle with it of 8″. This mountain is about two miles in perpendicular height above the level of the province of Quito, and near four miles above the level of the ſea. Though it is the largeſt mountain in the earth, yet it is about 7,400,000,000 leſs in bulk than the earth; and, its attraction on the plummet, if it is ſolid, ought to have been thirteen times greater than 8″; but, it is hollowed by ſubterraneous fires, which produce frequent volcanos; and which perhaps have made the whole mountain.

The mean effect of the attraction of the mountain Shehallien in Perthſhire is $5'', 8'''$; and, from its magnitude compared to that of the whole earth, it appears that the mean denſity of the earth is about double that of the mountain. The direction of Shehallien in length, is nearly eaſt and weſt, its height above the ſurrounding valley is, at a medium, about 2000 feet; and its higheſt part above the level of the ſea is 3550 feet.

Of the effect of the ocean upon the plummet, in ſuch ſituations as North America, and the Cape of Good Hope; and when it is ebb, or full ſea.

PROP. XII.

That the power of gravity reaches beyond the tops of the higheſt mountains, is certain from the fall of hail upon them, and from the return of bodies when thrown upwards from their tops.

SECT. II.

OF GRAVITY AT A GREATER DISTANCE FROM THE EARTH, THAN THE HEIGHT OF THE ATMOSPHERE.

PROP. I.

The effect of the power of gravity in the moon, and in the ſun, upon large ſurfaces of water in the earth, appears from the tides. See Hydroſtatics.

PROP. II.

In Aſtronomy, it is ſhown that the power of gravity reaches throughout the whole ſolar ſyſtem.

SECT. III.

THEORIES IN GRAVITATION.

An account of the various hypotheſes which have been formed concerning the immediate cauſe of gravity.

Remarks upon them, and irrefragable proofs that the great maſſes of matter, as well as the minute particles, are conſtantly governed by accurate laws, and wiſe deſign; whatever are the means employed for that end, by the Supreme Mind.

MECHANICS.

SECT. I.

GENERAL LAWS IN MECHANICS.

PROP. I.

Every body, or maſs of matter, continues in a ſtate of reſt, or of uniform motion, in a ſtraight line, till it is made to change that ſtate by ſome new force impreſſed.

PROP. II.

The change of motion in bodies is always proportional to the moving force impreſſed; and is produced in the ſtraight line in which that force acts.

PROP. III.

Action and re-action are equal and contrary, or there is a re-action equal to every action of one body upon another, and in a contrary direction; ſo that when a greater force acts contrary to a leſſer force, it will only produce a motion that is proportional to the difference of the two forces.

PROP. IV.

If a body is acted upon by two forces, the directions of which make an angle; if from that angle lengths are taken that are in the directions of the two forces, and in the ſame proportion to each other with the forces; and, if lines are drawn at the extremities of theſe lengths, ſo as to form a parallelogram; the body acted upon by this compoſition of motion, will move in the diagonal of that parallelogram.

Cor. The body will move through the diagonal in the ſame time that it would have moved through either of the contiguous ſides, if only one of the forces had acted upon it.

PROP. V.

The force by which any body moves in a ſtraight line may be reſolved into two other forces, that will be to each other as the ſides of a parallelogram of which that ſtraight line is the diagonal.

PROP. VI.

The motions and actions of bodies upon each other in a place that is carried uniformly forward, are the ſame as if that place was at reſt: and any powers or motions that act upon all the bodies ſo as to produce equal velocities in them, in the ſame, or in parallel lines, have no effect on their mutual actions or relative motions.

SECT. II.

OF THE CENTRE OF GRAVITY, MAGNITUDE, AND MOTION.

PROP. I.

The centre of gravity, in a homogeneous, circular plane body, globe, cylinder, parallelogram, and priſm, is the ſame with the centre of magnitude.

PROP. II.

In a homogeneous triangular plane body, the centre of gravity is at the diſtance from the vertex of two thirds of the line biſecting the oppoſite ſide. In a trapezium, at the point of interſection of lines joining the centres of gravity of the triangles into which the trapezium is divided. And in a cone and pyramid at the diſtance of three fourths of the axis from the vertex.

Of the centres of gravity in bodies of irregular figures, or of heterogeneous parts; and the manner of finding their centres of gravity by experiment.

PROP. III.

The common centre of gravity of two bodies is in a ſtraight line joining their reſpective centres of gravity, and the diſtance of their centres of gravity, from their common centre of gravity, is reciprocally as their quantities of matter.

PROP. IV.

In this manner, the common centre of gravity of three bodies may be found. Take the common centre of gravity of two of them that are next to each other, conſider it as the place in which the gravity of both is joined, from which to the centre of gravity of the third draw a ſtraight line, biſect this line reciprocally as the quantity of matter in the two bodies, and the quantity of matter in the third body; and this will be the centre of gravity ſought.

The centre of gravity of four, five, or any greater number of bodies may be found by a ſimilar method.

PROP. V.

If a perpendicular is drawn from the centre of gravity of a body to the horizon, and if it falls within the baſe upon which the body reſts, the body will ſtand; but if without the baſe, it will overſet, or fall.

Cor. 1. The larger the baſe is upon which a body reſts, and the farther within it the perpendicular falls, the firmer it will ſtand; and the leſs the baſe, or the nearer to its extremity the perpendicular falls, ſo much the more eaſily may it be overſet.

Cor. 2. Hence the reaſon why bodies of the ſame baſe, but unequal heights, ſtand, or fall, upon the ſame declivity, why ſome tumble, others roll, and others ſlide.

Cor. 3. When the centre of gravity of a body, or of a ſyſtem of bodies is ſupported, the whole body or the whole ſyſtem of bodies is ſupported; and their centres of gravity may be conſidered as the places which they occupy.

PROP. VI.

The centre of gravity, the centre of magnitude, and the centre of motion, may be in the ſame, or in different points of the ſame body.

PROP. VII.

When the centre of gravity and the centre of magnitude are not the ſame in a cylinder, it will roll up an inclined plane, if the right ſine of the angle which the plane makes with the horizon, is leſs than the diſtance of the centre of magnitude from the centre of gravity, the ſemi-diameter of the cylinder being radius.

PROP. VIII.

A double cone, the baſe of which has room to ſink in an inclined plane, will roll up that plane, if the right ſine of the angle of its elevation is leſs than half the diameter of the baſe of the cone.

PROP. IX.

The centre of gravity, and centre of motion, of a mariner's compaſs, of a lamp, of a marine chair, or of a time-keeper, may be ſo adjuſted, that they will anſwer the deſign of their conſtruction as machines, though a conſiderable and irregular motion be given to the bodies on which they are placed.

PROP. X.

If two bodies move equably in the ſame ſtraight line, and in the ſame or in contrary directions; or in two ſtraight lines, which are parallel to each other, or which make an angle, their common centre of gravity will either remain at reſt, or move equably in one ſtraight line.

PROP. XI.

The ſum of the motions of ſeveral bodies in any given direction, is the ſame as the motion of all the bodies in the ſame direction, when moved with the velocity of their common centre of gravity.

Of the centre of gravity in quadrupeds, birds, and men, when ſitting, ſtanding, at reſt, in motion, with or without burdens, and in a variety of attitudes that require agility or ſtrength.

PROP. XII.

Though animals have the power of changing their centres of gravity, according to the conſtruction of their bodies, and according to habits acquired, yet they are always ſubject to the laws above explained.

SECT. III.

OF THE DESCENT OF BODIES BY GRAVITY UPON INCLINED PLANES.

PROP. I.

A body will deſcend by gravity upon an inclined plane with a motion equably accelerated; allowance being made for the reſiſtance of the air, and the friction of the plane.

Cor. The velocities of a body deſcending by gravity upon an inclined plane are as the times. The velocities and times are in the ſub-duplicate ratio of the ſpaces, and the aſcent of a body upon an inclined plane from one impulſe is a motion equably retarded. See Gravitation, Sect. I. Prop. VI.

PROP. II.

The time of a body's deſcent by gravity upon an inclined plane is to the time of its deſcent in a perpendicular drawn from the height of the plane to a line drawn parallel to the horizon through the lower end of the plane, as the length of the plane is to the length of the perpendicular.

Cor. The times of deſcent upon different planes of the ſame height are as their lengths.

PROP. III.

If from the upper end of an inclined plane there is drawn a line at right angles to the horizon, and if from any point of that line there is drawn a perpendicular to the plane, a body will deſcend by gravity upon the plane from its higheſt point to that perpendicular in the ſame time that another body will move by gravity from the height of the plane to the point from which the perpendicular was drawn.

Cor. Hence the ſpace may be found through which a body will fall in the perpendicular, while another will fall through a given ſpace in the inclined plane; and, if there are two or more inclined planes, and a ſpace is taken in the firſt which is paſſed over in a given time, a ſpace may be found in the ſecond, or third, &c. which will be paſſed over in the ſame time.

PROP. IV.

When a body deſcends by gravity upon an inclined plane, it will acquire the ſame velocity, as if it had fallen through the perpendicular height of that plane.

Cor. The velocities acquired by bodies deſcending upon inclined planes of different lengths, are as the ſquare roots of their heights.

PROP. V.

If a ſtraight line is placed at right angles to the horizon, if a circle is drawn upon it as a diameter, and, if from the end of the diameter, chords are drawn to the circle, a body will move by gravity through each of theſe chords, in the ſame time that it will move through the diameter.

Cor. The times of deſcending through all the chords are equal.

SECT. IV.

OF PENDULUMS.

OF THE COMMON PENDULUM.

PROP. I.

When a pendulum oſcillates, it riſes to a height nearly equal to that from which it fell; till, by gradual diminutions of its velocity, it reſts in the loweſt point of the arch through which it moved.

Cor. The eye cannot perceive any difference in the oſcillations of the ſame pendulum, or of equal pendulums, through arches that are unequal, if the inequality is not great.

PROP. II.

A pendulum put in motion would oſcillate for ever, were it not for the friction at the pin, and the reſiſtance of the air; and, its oſcillations would not be affected by the quantity, or the kind of the matter in the ball.

PROP. III.

If pendulums are of the following lengths, their oſcillations in one minute of time in Britain are as follows,

Britiſh feet and inches.		Oſcillations.
0	1.565	300
0	9.782	120
3	3.128	60
13	0.512	30
52	2.048	15

Cor. 1. The oſcillations of pendulums are in

the ſubduplicate ratio, or as the ſquare roots, of their lengths; and, the lengths of pendulums are in the duplicate ratio, or as the ſquares of their oſcillations.

Cor. 2. In order to find the length of a pendulum that will oſcillate a certain number of times in a minute, make this proportion; as the ſquare of the given number of oſcillations is to the ſquare of 60, or the number of ſeconds in a minute, ſo let the ſtandard pendulum, or 39.128 inches, be to the pendulum ſought.

PROP. IV.

Though the difference in the continued oſcillations of the ſame pendulum cannot be ſeen in a few oſcillations, yet it is eaſily ſeen in a great number.

OF THE CYCLOID.

PROP. V.

All the oſcillations of a pendulum moving in a cycloid are equal, however unequal the arcs which they deſcribe; and, the oſcillations of a pendulum moving in a circle are equal, provided the arcs deſcribed are not larger than where the cycloid and the circle coincide.

OF THE ROD PENDULUM.

PROP. VI.

If a cylinder is ſuſpended at one end and put in motion, it will oſcillate in equal times with a common pendulum that is two thirds of its length.

Cor. A rod or bar will oſcillate in the ſame time that it would do, if the gravity of all its parts were collected in a point which is at two thirds of its length from the pin; and that point is called its centre of oſcillation.

PROP. VII.

All oſcillating bodies of whatever ſhape, have their centres of oſcillation; and the length of a pendulum muſt always be reckoned by the diſtance between the centre of ſuſpenſion, and the centre of oſcillation. If the ſtring, or wire of a common pendulum is very ſmall, when compared to the ball, its centre of oſcillation will be within the ball, and near its centre of gravity.

PROP. VIII.

When an obſtacle ſtops the centre of oſcillation, all the progreſſive motion of the pendulum is immediately ſtopped. But, when an obſtacle ſtops any other part of the pendulum, the centre of oſcillation tends forwards; and, by that tendency bends, or breaks the pendulum, if the force impreſſed is ſufficiently great.

Cor. Hence the centre of percuſſion; or that part of an inſtrument, or weapon, which will ſtrike with the greateſt force.

Of the differences in the oſcillations of pendulums of the ſame length, in different latitudes, ariſing from the figure of the earth, and the different degrees of centrifugal force communicated by the earth's motion. See Gravitation Sect. I. Mechanics Sect. VII.

PROP. IX.

If a pendulum that ſwings ſeconds at the equator is 39 Britiſh inches in length, the following table will ſhew the ſeconds nearly, which it will gain in

24 hours at different latitudes, and the lengths to be added to it in order to make it ſwing ſeconds at theſe latitudes.

Latitudes.	Seconds gained.	Inches to be added.
10	6.9	0,0062
20	26.7	0.0246
30	57.1	0.0516
40	94.3	0.0853
50	134.	0.1212
60	171.2	0.1549
70	201.6	0.1824
80	221.4	0.2033
90	228.3	2.2065

SECT. V.

OF A PENDULUM-STANDARD FOR WEIGHTS AND MEASURES.

PROP. I.

In the weights and meaſures of the moſt poliſhed nations, there is a great diverſity, though they have been regulated by law for many centuries.

The Engliſh ſtandards are kept in the Exchequer, and by the city of London; the Scottiſh, by the Magiſtrates of Edinburgh, Stirling, Linlithgow, and Lanark, with duplicates of them in the caſtles of Edinburgh, and Dumbarton; and, the Scottiſh are not only aſcertained by deſcribing the dimenſions of the veſſels, but by the weight of clear river water which they will contain.

At the Union of the kingdoms, it was enacted that the Engliſh weights and meaſures ſhall be uſed throughout the whole iſland, as the only ſtandards. Notwithſtanding this law, there is not only a great want of uniformity in the Britiſh weights and meaſures, but the ſtandards do not agree, though kept with ſo much care.

PROP. II.

BRITISH WEIGHTS.

TROY WEIGHT.

Grains.			
24	1 Penny weight.		
480	20	1 Ounce.	
5760	240	12	1 Pound.

The troy weight was formerly uſed for every purpoſe; but, it is now chiefly uſed for comparing different weights with each other; for making experiments in Natural Philoſophy; and, for weighing gold, ſilver, and jewels.

AVOIRDUPOIS WEIGHT.

Drachms.				
16	1 Ounce.			
256	16	1 Pound.		
28672	1792	112	1 Hundred.	
573440	35840	2240	20	1 Tun.

The pound avoirdupois contains 7000 grains troy. The ounce was formerly divided into eight drachms, and the drachm into three ſcruples; but, the preſent diviſion is into 16 drops or drachms. A ſtone is equal to 14 pounds, and 28 pounds, to a quarter of a hundred.

The tron weight is the moſt ancient of all thoſe uſed in Scotland; but it has long been prohibited by law. The Scotch troy weight was the ſame with that of Paris and Amſterdam; and is known by the name of Dutch weight. The Scotch troy pound contained 7600 Britiſh troy grains; which is equal to 17 ounces 6 drachms avoirdupois. The pound contained 16 ounces, and 16 pounds made a ſtone.

PROP. III.

Britiſh meaſures of length and ſuperficies.

Barley corns.						
3	1 Inch.					
36	12	1 Foot.				
108	36	3	1 Yard.			
594	198	16½	55½	1 Pole.		
23760	7920	660	220	40	1 Furlong.	
190080	63360	5280	1760	320	8	1 Mile.

Forty poles in length, and two in breadth, make a ſtatute acre, or 4840 ſquare yards.

The Scotch inch and foot were longer than the Engliſh in the proportion of 196 to 195. The Scotch mile was 5920 feet. The Scotch acre was larger than the Engliſh nearly as 5 to 4; but, if the difference of the Scotch and Engliſh foot is taken into the account, as 10 to 7,869.

PROP. IV.

Britiſh meaſures of fluids, or liquid meaſures.

Cubic Inches.						
231	1 Gallon.					
9702	42	1 Tierce.				
14553	63	1½	1 Hogſhead.			
19404	84	2	1⅓	1 Puncheon.		
29106	126	3	2	1½	1 Butt or Pipe.	
58212	252	6	4	3	2	1 Tun.

The Scotch pint contains 105 cubic inches, and the quart 210; and therefore, is about one tenth leſs than the Engliſh wine gallon, which contains 231.

Scotch Gills.					
4	1 Muchkin.				
8	2	1 Chopin.			
16	4	2	1 Pint.		
32	8	4	2	1 Quart.	
128	32	16	8	4	1 Gallon.

PROP. V.

Britiſh meaſures of ſolids, or dry meaſures.

Cubic Inches.				
268.8	1 Gallon.			
537.6	2	1 Peck.		
2150.4	8	4	1 Buſhel.	
17203.2	64	32	8	1 Quarter.

The ſtandard meaſure for corn in England is the Wincheſter gallon, which contains 268.8 cubic inches; and the Wincheſter buſhel, which contains 8 gallons or 2150.4 cubic inches. Eight buſhels make a quarter; four quarters a chaldron; five quarters a load; and ten quarters a tun.

There was formerly in Scotland only one meaſure of capacity for all ſolid bodies; but ſome of them were ſold by the exact internal capacity of the meaſure, and others were heaped. This laſt method was diſcharged by law, becauſe liable to abuſe; and larger meaſures were appointed in its place. Hence meaſures of the ſame denomination, for different things, are very different. Thus the barley firlot, or four pecks, contains 3208 cubic inches, and the wheat firlot only 2199 cubic inches, or about one hundred parts more than the Wincheſter buſhel.

PROP. VI.

A table of ſome foreign weights compared with the Britiſh pound avoirdupois.

	Avoirdupois libs.
100 pounds of Paris are equal to	108½
100 libs. of Lyons	93¼
100 libs. of Rome	78½
100 libs. of Turin	71¾
100 libs. of Amſterdam	108½
100 libs. of Geneva	121½
100 libs. of Sweden	92¾
100 libs. of Ruſſia	88¼

A table of ſome meaſures reduced to the toiſe, foot, inch, line, and decimal parts of a line; according to the ſtandard of the Royal Academy of Sciences in Paris.

	Toiſe.	Foot.	Inch.	Line.	Dec.
Britiſh foot	0	0	11	3	1154
Rhindland foot	0	0	11	7	183
Bologna foot	0	1	2	0	6
Swediſh foot	0	0	10	11	75
Chineſe royal foot	0	0	11	9	9
Ancient Roman foot	0	0	10	10	9
Ancient Greek foot	0	0	11	4	56
Arabian foot	0	0	9	10	72
Alexandrian foot	0	1	1	2	9

	Toiſe.	Foot.	Inch.	Line.	Dec.
Britiſh mile	830	0	0	0	0
Modern Roman mile	764	0	0	0	0
Ancient Roman mile	766	0	0	0	0
Italian geographic mile	958	0	0	0	0

Of the difficulty of preſerving a correct general ſtandard, according to the practice that prevails in Europe.

Of the advantages that would ariſe to commerce and philoſophy, if one ſtandard was uſed for weights and meaſures in all countries.

PROP. VII.

Meaſures of length, and ſurface, might be taken from a pendulum that oſcillates ſeconds under the equator, or in a place that does not belong to rival nations; and, it might be divided and ſubdivided, into decimal parts with eaſe and accuracy

From this univerſal ſtandard, national ones might be made of bars of glaſs, or bars of copper, &c. having the ſame denſity and varniſh, and the ſame degree of heat when uſed.

Meaſures of capacity might be hollow cubes of copper, &c. from the ſame ſtandard and its diviſions, with checks from the weight of fluid bodies.

Weights might be ſolid cubes of copper, &c. from the ſame ſtandard; while the names uſed in every country might be retained as much as poſſible.

The national ſtandards might be corrected by ſecond-pendulums in the reſpective capitals; and, if diſputes ariſe concerning the accuracy of the national ſtandards, they might be verified by commiſſioners ſent from different nations to the ſtandard latitude.

SECT. VI.

OF PROJECTILES.

PROP. I.

When a body is projected, with a ſmall force, in an oblique, or horizontal direction, its path is a parabola.

Of the path of a body when projected in order to ſtrike an object at the diſtance called point blank; and at a diſtance which requires an elevation.

PROP. II.

Though projectile forces are very different in their nature, as that of a man's arm, a bow, a gun, yet they may all be reduced to a ſimilar and accurate ſtandard by gravity, or that velocity which the projectile acquires by falling through a perpendicular to the horizon of a certain height; which is called its impetus.

PROP. III.

When the impetus of a projected body is the ſame, the greateſt amplitude or range is with an angle of elevation of 45°.

PROP. IV.

The amplitudes are equal which are made with any angles of elevation at equal diſtances from half a right angle, if the impetus is the ſame.

Cor. Of two elevations with equal amplitudes, that one may be taken by which a projectile will reach the mark, when, with the other elevation, it could not reach the mark on account of a body interpoſed. And, when there is no body interpoſed, that elevation may be choſen which will produce the effect required, with the greateſt advantage.

PROP. V.

With the ſame angle of elevation, the amplitude of a projected body, is as the ſquare of the impetus. See Hydroſtatics. Sect. 1.

PROP. VI.

The greateſt altitude of a body that is projected at right angles to the horizon, is equal to half the greateſt range, if the impetus is the ſame at both projections.

Cor. Hence the height may be known to which a body will riſe, that is projected at right angles to the horizon.

PROP. VII.

If the ſtandard line, or impetus of a projectile, is placed at right angles to the horizon, if a ſemi-circle paſſing through its extremities, is inſcribed upon it, if from its lower end there are drawn chords as lines of elevation to the projectile, if from the points where the chords meet the ſemi-circle there are drawn perpendiculars to the impetus; then four times theſe perpendiculars will be the greateſt range; and the diſtances of the points where the perpendiculars meet the impetus from its loweſt end, will be the greateſt altitude of the projectile with the correſponding elevation.

Cor. 1. The errors of amplitude are leſs with an elevation at 45°, than with any other elevation.

COR. 2. The amplitude, and direction being given, the impetus and altitude may be found. The impetus, and amplitude being given, the direction and altitude may be found. And every thing that relates to the impetus, elevation, amplitude, and path, whether the mark to be hit is in the ſame horizontal plane with that from which the body is projected, or above, or below it.

Of the reſiſtance of the air to projectiles with great velocities, ſuch as ſtones, cannon balls, and bombs.

PROP. VIII.

It is found by experiments, that if a cannon ball of 24 libs. is impelled by its uſual charge, the reſiſtance of the air to its motion is at leaſt equal to a weight of 400 libs.: That this reſiſtance continually diminiſhes its velocity: That if it is impelled at an elevation of 45°, its range is not a fifth part of what it would be, could the air be removed: That the ſwifter it moves, the greater is the reſiſtance of the air; and in the duplicate ratio of the velocity: That when the velocity is greater than 1200 feet in a ſecond of time, the reſiſtance is three times greater, and is ſubject to a new law: That an increaſe therefore of the initial velocity does not make a proportional increaſe in the range: That as there is a great reſiſtance in the front of the ball, leſs at the ſides, and a vacuum behind, it deviates to the ſide where the oppoſition is leaſt, till it condenſes the air in its new path, as before. That if a ball of 24 libs. is thrown at an angle of 45° with its greateſt charge, its range is about 440 yards leſs than three

Britiſh miles: That when the elevation is only $7°\frac{1}{4}$, and the charge equal each time, there is ſometimes a difference in the ranges of more than 700 yards: And, that when every thing is made as much alike as poſſible, the paths of two balls on the horizontal plane make ſometimes an angle with each other of 15°.

Of perforated ſpheroidical ſhot, and perforated ſpheroidical bombs, with the manner and advantages of throwing them.

SECT. VII.

OF CENTRAL FORCES.

PROP. I.

Centrifugal and centripetal forces acting upon the ſame body may overcome each other; or, they may be in ſuch proportions, that the body acted upon will revolve in the ſame path.

PROP. II.

When a body that is acted upon by a centrifugal and a centripetal force, recedes from the centre by the firſt force, or accedes to it by the ſecond, its path is a ſpiral line. If the firſt is ſuſpended, the body will move towards the centre. If the ſecond is ſuſpended, it will fly off in a tangent.

PROP. III.

A body will revolve in an ellipſe, by the compoſition of a projectile force and centripetal force acting upon it; and, if a ſtraight line is drawn from the body, to the focus of the ellipſe, that line will deſcribe areas proportional to the times in which the body moves.

PROP. IV.

If two bodies are moved by centrifugal and centripetal forces, and, if their periodic times, their quantities of matter, and diſtances from the centre are equal, their centrifugal forces will be equal.

PROP. V.

When the periodic times, and quantities of matter, in two bodies are equal, but their diſtances from the centre unequal, their centrifugal forces are as their diſtances.

PROP. VI.

If the diſtances, and periodic times of two bodies are equal, but their quantities of matter unequal, their centrifugal forces will be as their quantities of matter.

PROP. VII.

The centrifugal forces of ſuch revolving bodies are in direct proportion to their quantities of matter multiplied into their reſpective velocities; or into their diſtances from the centres of their reſpective orbits.

Cor. If the periodic times are equal, and the diſtances from the centres reciprocally as the quantities of matter, the centrifugal forces will be equal.

PROP. VIII.

When the quantities of matter in revolving bodies, and the diſtances from the centre, are equal, but the periodic times unequal, the centrifugal forces are reciprocally as the ſquares of the periodic times, or as the ſquares of the velocities.

PROP. IX.

If the quantities of matter in revolving bodies are equal, and the periodic times unequal, but ſuch that the ſquares of the times are as the cubes of the diſtances; the centrifugal forces will be inverſely as the ſquares of the diſtances.

PROP. X.

When two, or more, bodies are joined together, or connected, by any force, if they revolve round each other, they will revolve round their common centre of gravity, as their common centre of motion.

PROP. XI.

When any number of bodies is carried round in a vortex, the matter of which is denſer than that of the bodies, they will run into the centre in a ſpiral line; when it is not ſo denſe, they will recede from the centre in a ſpiral line; and, when it is of the ſame denſity, they will have their periodic times equal, whatever their diſtances are.

PROP. XII.

A globe will become oblate at the poles, if it is made to revolve upon its axis, and with a velocity ſo great that its centrifugal force can overcome its centripetal.

SECT. VIII.

OF THE MOMENTUM AND COLLISION OF BODIES.

PROP. I.

The momentum of a body is in a ratio compounded of its quantity of matter and velocity. And the momentums of different bodies, are to each other in the ſame proportion as the numbers got by multiplying their reſpective quantities of matter into their velocities.

COR. If the quantities of matter, and celerities, of two bodies are reciprocally proportional, their momentums will be equal, however unequal their quantities of matter.

PROP. II.

The momentums of bodies may be the ſame, and their effects may be very different, according to the forms, bulks, and coheſions of the bodies on which they act, and the times in which their forces are ſpent.

PROP. III.

There are no bodies on which experiments have been made that are perfectly non-elaſtic, elaſtic, or hard.

PROP. IV.

If a non-elaſtic body impinges directly on a non-elaſtic body that is at reſt, or moving with leſs velocity the ſame way, the ſum of the momentums will be the ſame before, and after, the impulſe.

PROP. V.

When two non-elaſtic bodies impinge directly on each other with contrary motions, the ſum of the momentums after the impulſe is equal to their difference before it.

PROP. VI.

If the ſum of two conſpiring motions, or the difference of two contrary motions, is divided by the ſum of the quantities of matter in non-elaſtic bodies, of which the colliſion is direct, the quotient will give their common velocity after the ſtroke; and, if the velocity after the ſtroke is multiplied into the quantity of matter in each body, the products will expreſs the momentum of each body after the ſtroke.

PROP. VII.

When elaſtic bodies are ſtruck, they change their figure, and recover it again; and, the elaſtic power of the ſame body exerts itſelf in one conſtant proportion to the compreſſing force.

Cor. The reſiſtance of elaſtic bodies is proportional to the ſpace through which they are forced.

PROP. VIII.

When an elaſtic body impinges directly againſt an equal elaſtic body that is at reſt, it communicates its whole velocity to the other, and remains at reſt itſelf. If it impinges directly againſt the other when moving with leſs velocity the ſame way, they will exchange velocities after the impulſe, and continue in the ſame direction as before.

PROP. IX.

If two equal and elaſtic bodies impinge directly againſt each other with equal velocities, they will recede from each other with the ſame velocities. If with unequal velocities, they will exchange velocities, and move after the impulſe in contrary directions.

PROP. X.

In order to determine the velocity of elaſtic bodies, after their impulſe, whether equal, or unequal, find the common velocity with which they would move if they were non-elaſtic, and find the velocity loſt, or gained; then ſubtract the velocity loſt from the common velocity, or, to the common velocity add the velocity gained, and the difference, or the ſum, will be the velocity ſought. But, if the velocity loſt is greater than the common velocity, ſubtract the common velocity from the velocity loſt, and the remainder will give the velocity loſt in a contrary direction.

PROP. XI.

When an elaſtic body impinges againſt a ſoft obſtacle, or, when it impinges againſt an elaſtic body that reſts upon a ſoft obſtacle, the effect is deſtroyed, and it does not rebound.

Cor. Hence the effect of placing anvils upon ſoft bodies.

PROP. XII.

If there is a ſeries of elaſtic bodies, and if one, or two, or more, at one extremity of the ſeries, is impelled againſt the reſt, an equal number will fly off, and with the ſame velocity, from the other extremity.

PROP. XIII.

When an elaſtic body ſtrikes againſt a hard, or an elaſtic plane, in a path that is at right angles to the plane, it rebounds in the ſame path. When it ſtrikes obliquely againſt the plane, the angle of reflection is equal to the angle of incidence.

PROP. XIV.

If elaſtic bodies ſtrike obliquely againſt each other, their paths, velocities, and momentums, after the ſtroke, may be determined by the above rules, and by Prop. IV. and V. in Sect. I.

SECT. IX.

OF THE SIMPLE MECHANIC INSTRUMENTS.

OF THE LEVER.

PROP. I.

When a power and weight act perpendicularly upon a lever, and are reciprocally to each other as their diſtances from the prop, if the power is increaſed it will give motion to the weight; or, if the weight is increaſed, it will give motion to the power, whether the prop is between the weight and the power, or the weight between the power and the prop, or the power between the prop and the weight; which poſitions of the power, weight, and prop make levers of three kinds.

Cor. 1. The velocities of the power and weight are as their diſtances from the prop.

Cor. 2. A ſmall power may raiſe a great weight, if the length of the lever, and the ſpace to be paſſed through by the power, can be increaſed in the proportion required by the propoſition.

PROP. II.

When a lever is bent, or is made up of parts that do not ly in one ſtraight line, the diſtances of the power and weight from the prop muſt be eſtimated by perpendiculars from the prop to the lines of direction of the power, and weight reſpectively.

PROP. III.

In a ſteelyard, the matter on one ſide of the prop ought to ſuſtain the matter on the other, and the centre of gravity ought to be a little below the centre of motion; and then, according to Prop. 1. it is fit for aſcertaining the weight of bodies.

PROP. IV.

In a common balance the friction ought to be ſmall, the arms of equal lengths, the ſcales and ſtrings of equal weights, the centres of gravity and motion different, and the centre of motion ought not to be above the points of ſuſpenſion of the ſcales; for by not obſerving theſe rules, a balance will be inaccurate, or falſe.

Of many common inſtruments that are levers of the different kinds; and the bones of animals which are levers of the third kind.

Of the oar, which is a lever of the ſecond kind; and of diſguiſed levers.

OF THE WHEEL AND AXLE.

PROP. V.

When a power, and weight are applied to the wheel and axle, the power will ſuſtain the weight, when the power is to the weight, as the diameter, or as the circumference, of the axle, is to the diameter, or to the circumference, of the wheel.

COR. If a rope is coiled round the axle, or round the wheel, the addition made by it to their diameters muſt be taken into the account. And, in order to work the wheel and axle continually with the ſame advantage, the power muſt be increaſed, as the rope increaſes the diameter of the axle, and in the above proportion.

OF THE PULLEY.

PROP. VI.

No advantage is given to the power by a ſingle upper wheel, when conſidered as a ſimple inſtrument; but there are other advantages gained, to wit, a ſmooth motion to the weight, leſs wearing of the rope; and, by it, a man can do more work, on account of the make of his body.

PROP. VII.

A ſingle under wheel gives an advantage to the power over the weight, as two to one.

PROP. VIII.

In a combination of upper, and under wheels, when one rope runs through all the wheels, the power will ſuſtain the weight, when the power is to the weight as unity to the number of folds in the rope, leſs by one; and conſequently, if either the power, or the weight is increaſed, it will prevail.

PROP. IX.

When each under wheel has its own rope, one end of which is fixed in the cieling, and the other in the block of the next wheel, the power, and weight will ſuſtain each other, if the power is to the weight as unity to the number two multiplied into itſelf as often as there are under wheels.

PROP. X.

If one end of the rope of an upper wheel is fixed in a weight, and the other end in the block of a ſecond upper wheel; if the rope of this wheel is fixed in the weight as the firſt was, and if a power is applied to the other end, the power will be to the weight as three to one. If more wheels are added of the ſame kind, and with ropes fixed in the ſame manner, each wheel will double the advantage to the power, and with the addition of unity; that is, three wheels will make the power as 7, four as 15, five as 31.

Cor. In all the combinations of the wheels, the power and weight are to each other reciprocally as their velocities.

Of the advantages and diſadvantages of different combinations of wheels; and, of the beſt method of fitting them up for uſe.

OF THE INCLINED PLANE.

PROP. XI.

If a power which acts in a direction parallel to an inclined plane, is to the weight to be raiſed, as the perpendicular height of the plane is to its length, the power will ſuſtain the weight; and if increaſed will move it upwards.

Cor. By the inclined plane, weights may not only be raiſed, but by it, as with the lever, a very ſmall power will ſuſtain a very great weight, when they are to each other as the height of the plane is to its length, or as the right ſine is to the radius; the lower extremity of the plane being the centre.

OF THE WEDGE.

PROP. XII.

All bodies to which the wedge is commonly applied may, at a medium, be reduced to three kinds.

Such as do not fly before the wedge, ſo that every part of the cleft is in contact with it; ſuch as fly to the middle of the wedge, ſo that the upper half of its ſides are in contact with the cleft; and, ſuch as fly ſo much that no part of the cleft is in contact with the wedge, but at its upper extremity. An example of the firſt kind is wet clay; of the ſecond, ſoft timber; and, of the third, elaſtic wood.

In the ſingle wedge, the power, that is, the momentum of the hammer and wedge, will be equal to the reſiſtance, that is, to the coheſion of the body to be cloven, with the weight of the matter to be moved, and, if increaſed will overcome it; when the power is to the reſiſtance, as the perpendicular length of the cleft is to the hypotheneuſe of the triangle formed by the cleft at every ſtroke. And,

In the double wedge, as double the perpendicular length of the cleft to the ſum of the ſides of the triangle formed by the cleft.

Of the time in which the power produces its effect, which will vary theſe proportions. Of the reſiſtance, according as it is direct, or oblique; and the method of eſtimating the varieties which ariſe from theſe circumſtances.

Of the imperfections of the machines commonly uſed for explaining the power of the wedge, which muſt be aſcertained, not by them, but by a ſeries of experiments, upon bodies of different kinds.

OF THE SCREW.

PROP. XIII.

When the power applied to the ſcrew is to the weight or reſiſtance, as the diſtance between two of the neareſt threads meaſured lengthwiſe upon the axis, is to the ſpace deſcribed by the power, they will ſuſtain each other; and, if the power is increaſed, it will move the weight, or overcome the reſiſtance.

Cor. If the diſtance between two of the neareſt threads is diminiſhed, the power will be increaſed; or, if the diſtance is increaſed, the power will be diminiſhed, and in exact proportion.

PROP. XIV.

In the perpetual ſcrew and wheel, if a weight acts at the circumference of the wheel, the power will ſuſtain the weight; when the power is to the weight as the diſtance between two of the neareſt teeth of the wheel, is to the path deſcribed by the power.

PROP. XV.

All the mechanic inſtruments are not equally fit for producing the ſame effect, ſo that a choice muſt be made, according to the effect required.

Though a power may be increaſed by the application of a mechanic inſtrument, yet a greater effect cannot be produced by it in the ſame time; but the time muſt be increaſed in the direct ratio of the increaſe of the power.

The gravity of the matter of which the inſtrument is made muſt be added, or ſubtracted, according as it is for, or againſt the power.

The friction of the inſtrument muſt be ſubtracted from the power.

If the inſtrument is increaſed in ſize, an allowance muſt, in ſome caſes, be made for its diminiſhed ſtrength, though the proportions be the ſame.

SECT. X.

OF COMBINED MECHANIC INSTRUMENTS OR MACHINES.

PROP. I.

In a combination of levers, the power will ſuſtain the weight, when the power is to the weight as the diſtance of the weight from the next prop is to the powers of all the levers multiplied into each other.

PROP. II.

When wheels and axles are combined, the power will ſuſtain the weight, if the power is to the weight as the product of the diameters of all the axles, leaves, pinions, or trundles, to the product of the diameters of all the wheels or cylinders.

PROP. III.

The method of combining pulleys, inclined planes, powers for wedges and for ſcrews, together with the advantages of the combinations, are eaſily explained upon the principles above eſtabliſhed.

PROP. IV.

In every machine, the power will ſuſtain the weight, when the velocity of the power is to the velocity of the weight, as the weight is to the power; and if a power is given, a greater weight may be moved with leſs velocity, or a leſs weight with a greater velocity, but not otherwiſe.

PROP. V.

If the power which moves a machine, acts within it, and exerts its force againſt an external object, the power to move the machine will be the ſame as if the machine was at reſt, and the object was to be moved, ſuppoſing both of them equally moveable. But if the power acting within a machine is not communicated to an external object, no motion will be given to the machine.

SECT. XI.

OF THE STRENGTH OF TIMBER AND ROPES.

PROP. I.

The lateral ſtrength of any piece of timber, the ſection of which is a right angle, is directly as the breadth, and the ſquare of the depth.

PROP. II.

In ſquare timber, the lateral ſtrength is as the cube of the breadth or depth.

PROP. III.

When a weight is laid upon a ſtraight beam which is ſupported at both ends, its bending is nearly as the weight and length directly, and as the breadth and ſquare of the depth reciprocally.

PROP. IV.

If one end of a beam is fixed in a wall, and a force is applied to it laterally, the ſtreſs upon any place will be directly as the force, and its diſtance from the wall.

PROP. V.

If two beams are placed ſo as to make the two ſides of an iſoſceles triangle, of which the baſe is in a horizontal plane; if a weight is equally placed over them, or laid upon their middle; the ſtreſs upon the beams will be as their lengths, as the coſines of the angles which they make with the horizon, and as the weights.

Cor. From theſe propoſitions, we may ſee how to ſave timber, and gain ſtrength, in erecting machines, and building houſes, and ſhips.

PROP. VI.

The lateral ſtrength of a hollow cylinder is to that of a ſolid cylinder, as the ſection of the firſt excluding the bore, to the ſection of the ſecond, and the diameter of the firſt to the diameter of the ſecond nearly.

Cor. Hence the greater ſtrength acquired by forming the ſame maſs of matter into a tube inſtead of a ſolid cylinder of the ſame length, when the increaſe of the ſize is not inconvenient; and hence the ſtrength of ſome bones, and vegetables.

PROP. VII.

A piece of good oak taken lengthwiſe without knots, an inch ſquare, and a yard long, and ſupported at both ends, will bear in the middle 330 libs.; but it ſhould not be loaded with above a third part of that weight for a long time.

Wood is weaker when green than when dry; the wood of the branches is weaker than that of the trunk; and the heart of the tree when freſh and ſound, is the ſtrongeſt of all.

The relative ſtrength of the different kinds of wood is at a medium, as follows; oak as 12; yew as 11; aſh as 10; elm as 9; walnut as 8; fir, alder, plane as 7; beech, hazel, birch, willow as 6.

Cor. Hence machines cannot be increaſed to any bigneſs: joiſts of a certain length would break; and trees, and animals of a certain magnitude would fall to pieces by their own weight.

Of the method of ſupporting great weights and extended beams, in houſes and wooden bridges, by checks, and girders.

PROP. VIII.

A rope of hemp, an inch in circumference, will bear 100 libs.; and the increaſe of the ſtrength of ropes, if very good, is nearly as the ſquares of their diameters; but neither beams, nor ropes ſhould bear for a long time, more than a third part of what they will eaſily bear, when freſh, and newly made.

Of fixing ropes in machines; and of the beſt method of making knots.

SECT. XII.

OF FRICTION.

PROP. I.

The ſofter, or rougher, the bodies are which rub upon each other, the greater, in general, is their friction. If their preſſure is increaſed, their friction will be increaſed in the ſame ratio, all other circumſtances being equal. If their velocity is increaſed, their friction will be increaſed, but not in the ſame proportion: and the increaſe, or dimunition, of the ſurfaces makes, in general, no change in the friction while the preſſure and velocity are the ſame.

PROP. II.

Wood ſlides more eaſily upon the ground or earth, in wet weather than in dry; and more eaſily than iron, in dry weather; but iron more eaſily than wood in wet weather. A cubic piece of ſmooth ſoft wood, eight pounds in weight, moving upon a ſmooth plane of ſoft wood, at the rate of three feet every ſecond, has a friction equal to above two thirds of its weight: Soft wood upon hard wood, has a friction equal to one ſixth part of its weight: And hard wood upon hard wood, has a friction equal to about one eight part of its weight.

PROP. III.

In wood rubbing upon wood, oil or greaſe properly applied, makes the friction about two thirds leſs. Wheel naves, when greaſed, have four times leſs friction than when wet.

PROP. IV.

When poliſhed ſteel moves on ſteel, or pewter properly oiled, the friction is about one fourth of the weight; on copper or lead, one fifth of the weight; on braſs, one ſixth; and metals have more friction when they move on metals of the ſame kind, than when they move upon different metals.

PROP. V.

Ropes moving in machines differ in their friction according to their ſtiffneſs, their greaſe, and the ſtate of the weather. The difficulty of bending a rope is as the ſquare of its diameter and tenſion directly, and reciprocally as the diameter of the cylinder, or wheel, upon which it moves. A rope one inch in diameter, the tenſion of which is made by five pounds over a wheel three inches in diameter, requires the weight of one pound to bend it.

PROP. VI.

The friction of the lever is eaſily eſtimated by the above propoſitions.

The friction of the wheel and axle is as the weight, the velocity, and the diameter of the axle.

The friction of the pulley is as the weight, the velocity, the diameter of the wheel inverſely, and the diameter of its axle directly. 15 lbs. with an upper wheel, will raiſe 14 lbs.; and 150 lbs. with a pulley of five folds, will raiſe 500 lbs. provided the axles and holes are not much worn.

The friction on the inclined plane, is according to the matter and ſurface of which the plane and weight are made, as above explained.

The friction of the wedge, and the friction of the ſcrew is, at leaſt, equal to the power, when they retain the poſition which they have gained.

PROP. VII.

In order to eſtimate the friction of any machine, conſider the weight and velocity at the firſt rubbing part, and eſtimate the quantity of friction in the method above explained. Proceed in the ſame manner to the next rubbing part, and ſo through the whole machine, making an allowance for the increaſe of friction by every addition to the power.

Of friction wheels; and other means of diminiſhing friction beſides oil, and greaſe.

SECT. XIII.

OF MODELS OF MACHINES.

PROP. I.

Models may be made which will repreſent the proportions, and poſition of the parts of machines, but without their motions, that is, they are not working models.

PROP. II.

Machines in miniature, may be intended not only to give a clear conception of large machines that are to be made in imitation of them, but in order to aſcertain the manner in which they will work.

PROP. III.

A working model may ſatisfy the expectations of the inventor, and yet, a large machine made like it, may not work, or may break in pieces; becauſe the friction, or the relative ſtrength of the parts may not be the ſame that they were in the model, though the proportions in the parts of both are exactly the ſame.

SECT. XIV.

OF POWERS APPLIED TO MACHINES.

PROP. I.

When the moving force is a weight, a ſpring, water, or air, the law by which it acts is aſcertained in Gravitation, Mechanics, Hydroſtatics, or Pneumatics.

PROP. II.

A man of ordinary ſtrength, turning a roller by the handle, can eaſily work for a whole day againſt a reſiſtance equal to 30 lbs. If he works ten hours in a day, he will raiſe that weight three feet and a half in one ſecond of time; or if the weight is greater, he will raiſe it ſo much leſs in proportion. He may act for a ſhorter time againſt a reſiſtance of 50, 60, or 70 lbs. If the weight of his own body is 140 lbs. he can draw about the half of that weight horizontally. If he is accuſtomed to carry burdens, he will carry from 200 to 300 lbs.; according to the manner in which he is loaded.

If two men work at a windlaſs, or roller, they will more eaſily raiſe 70 lbs. than one man will raiſe 30 lbs. provided the elbow of one of the handles is at right angles to that of the other; and, with a fly or wheel applied, they will do a third part more work than without one; unleſs the machine is more accurately made than thoſe that are in common uſe.

PROP. III.

The ſtrength of a horſe is commonly equal to that of five men; and he can eaſily carry from 250 to 300 lbs. He can draw to greateſt advantage, when the line of draught makes a ſmall angle with the horizon, and when he draws by his breaſt. In a gin he can draw 200 lbs. for eight hours in a day, at the rate of two miles and a half every hour. The worſt way of applying his ſtrength, is to make him carry, or draw, up a ſteep hill; becauſe three men each carrying 100 lbs. up the hill, will go faſter than he can with 300 lbs. Though he can draw in a circular path, that is eighteen feet in diameter, he ought not to work long in one that is leſs than thirty feet, on account of the ſtrain that is given to his body in a ſmall circle.

Of the ſtrength of oxen, and mules, and the beſt way of applying their ſtrength.

SECT. XV.

OF INSTRUMENTS AND MACHINES FOR WAR.

PROP. I.

The ſword, ſpear, dart, javelin, bow, arrow, ſling, and the method of uſing them to moſt advantage explained upon mechanical principles.

Of bucklers, ſhields, targets, helmets, coats of mail, and the difficulty of making them both light, and defenſive.

Of the teſtudo, muſculus, crates, pluteus, vinea, and other defences of that ſort, which were uſed by the ancients.

PROP. II.

An explanation, by working models, of the battering ram, catapulta, and baliſta of different kinds.

PROP. III.

The momentum of a battering ram againſt the wall of a town was equal to that of the battering ſhot of a cannon; and, the momentum of darts, iron balls, and ſtones, thrown by the catapulta and baliſta, was equal to the momentum of muſket ſhot, and ſmall bombs, if their quantities of matter and velocities were reciprocally proportional; and, it is probable, from the conſtruction, and effects, of theſe ancient machines, that they were ſo.

Models of the moveable penthouſes of the ancients by which they defended their battering rams; and of their moveable towers, by which the aſſailants were raiſed above the walls of the beſieged.

PROP. IV.

An ancient fortified town, and its attack and defence, deſcribed by models.

Of the principles of attack and defence, whatever inſtruments of war are uſed; and, of thoſe peculiar to the moderns ſince the invention of gun powder.

PROP. V.

Muſkets, cannon, mortars, ſhot, bombs, explained by models, and their effects deſcribed.

Of perforated ſpheroidical ſhells, which produce the double effect of balls and bombs at the ſame time, and with great certainty.

PROP. VI.

The implements of defence uſed by the moderns in their ſieges, explained by models.

PROP. VII.

A deſcription of a model of a modern fortified town, with its attack and defence.

SECT. XVI.

OF INSTRUMENTS AND MACHINES FOR AGRICULTURE.

PROP. I.

The ſpade, and plough of different kinds reduced to the mechanic inſtruments, and explained by models.

PROP. II.

A deſcription of other inſtruments and machines for agriculture; with the theory of their mechaniſm, and advantages.

SECT. XVII.

OF CARRIAGES OF DIFFERENT KINDS.

PROP. I.

Sleds, cars, carts, waggons, coaches, explained, and the principles of their conſtruction.

PROP. II.

A wheel carriage is drawn by the leaſt power when the line of draught paſſes through the centre of gravity of the carriage, and parallel to the plane on which it moves.

Cor. Hence a rule for the ſize of the wheels of carriages of every ſort; but, when a horſe is the power, he, from the make of his body, draws with moſt advantage when the traces, or the ſhafts, make a ſmall angle with a plane that paſſes through the axle of the wheels, and parallel to the road.

PROP. III.

A carriage is more eaſily drawn with four equal wheels, than when the two fore wheels are ſmaller than the two hind wheels; but more room is required for turning it.

PROP. IV.

If the fore wheels of a carriage are leſs than the hind wheels, it is drawn upon an horizontal plane with greater eaſe, when the load is placed behind, than when before.

PROP. V.

When a carriage is drawn up a hill, or upon an inclined plane, the power will ſuſtain the weight, that is, the carriage and the load, if the power is to the weight as the height of the plane, or the ſine of the angle which the plane makes with the horizon, is to the length of the plane.

Though there is an advantage in loading a carriage behind, which is drawn upon an horizontal plane; yet if it is drawn up and down hill, without ſhifting the load, the moſt advantageous average poſition of the load is in the middle, or when equally ſpread over the whole carriage.

PROP. VI.

No advantage is derived from broad wheels upon a very ſmooth, hard, road; but, upon a ſoft road, their advantage over narrow wheels is very great, both to the cattle, and to the road.

PROP. VII.

The beſt method of making roads explained; and the great diſadvantage of making ſtraight-line roads for carriages in a hilly country.

PROP. VIII.

In Glaſgow, and its neighbourhood, a ſingle horſe, on a level turnpike road, draws 25 cwt. in a cart that weighs about 10 cwt. having wheels ſix feet high, and its axle paſſing through the centre of gravity of the load and cart, but, in a common cart, he draws only the half of that load. Two horſes, yoked in a line, in a common cart, eaſily draw 30 cwt. upon an uneven road. And ſix horſes, yoked two a-breaſt, draw 80 cwt. in a common waggon.

Cor. Six horſes, in ſix carts, with high wheels, can draw 150 cwt. on a level road; and, ſix horſes, in three common carts, with two horſes in each, can draw, upon an uneven road, 90 cwt. that is, 10 cwt. more than they can do in a waggon; the weight, tear and wear, and the eaſe in driving a waggon, or three carts, being, it is ſaid, nearly equal; and the price of the three carts being leſs than that of the waggon.

Of the beſt method of drawing great weights through rocky, or through marſhy countries, where there are no roads, or where they are much broken.

SECT. XVIII.

OF MACHINES FOR ARCHITECTURE.

Of the architecture of different ages, and countries, and the principles of building wooden, brick, and ſtone houſes.

PROP. I.

The foundation of houſes ought to be ſecured from water and froſt; and, when it is looſe, piles ought to be driven, and platforms laid, to make it ſolid, and to unite and extend the preſſure of the whole building.

PROP. II.

An explanation of working models of the machines for driving piles.

Of the ſtrength of the walls, and roofs of houſes. Of cements to be uſed according to the nature of the foundation, wall, and climate.

PROP. III.

The principles and conſtruction of piers, arches, and bridges explained by models.

PROP. IV.

Piles may be driven, platforms laid, and ſtone foundations built, below the bed of a river, and piers may be raiſed, upon them, with every conveniency for maſons to work, and full time for the cement to dry; and yet the courſe of the river need not be changed.

PROP. V.

Wooden bridges explained by models, and the principles of their conſtruction.

SECT. XIX.

OF MACHINES FOR MANUFACTURES.

PROP. I.

The effect of centrifugal motions, and of different quantities of matter, upon machines of various ſorts, explained upon the principles of central forces, as in Sect. VII.

PROP. II.

The common ſpindle and diſtaff, the ſpinning wheel, the twiſting mill, &c. explained in the ſame manner.

Other machines for manufactures, and their mechaniſm deſcribed.

SECT. XX.

OF MACHINES FOR MEASURING TIME.

Of meaſuring time by the heavenly bodies, and by the ſhadow of the ſun.

PROP. I.

A deſcription of lamps, candles, clepſydras, ſand glaſſes, &c. for meaſuring time.

PROP. II.

The mechaniſm of clocks, watches, and timekeepers of different kinds, with their improvements, explained by models.

Of clocks, without a librator, pendulum, ſpring, or weight, which meaſure ſeconds, minutes, and hours, by the drops of fluids.

SECT. XXI.

OF SPHERES OF THE WORLD.

PROP. I.

A deſcription of globes, armillary ſpheres, and other machines of that ſort, which have been contrived for explaining the phenomena of the heavens. See Aſtronomy.

PROP. II.

An account of the ſphere, or planetarium, which was made by Archimedes; and of ſimilar machines, by Poſidonius, Severinus Boethius, &c. till the end of the ſeventeenth century.

Of the clock made by Graham, which gave riſe to the calling, by the name of orrery, ſuch machines as exhibit the motions of the heavenly bodies.

PROP. III.

The mechaniſm of orrerys, and of planetariums explained.

SECT. XXII.

OF PERPETUAL MOTIONS.

PROP. I.

A deſcription of machines, and of models of machines, which have been contrived in order to move continually, without an external power acting upon them.

PROP. II.

The cauſes ſhown of the want of ſucceſs in ſuch attempts; and the uſeleſsneſs of ſuch machines, though they could be made in the way commonly propoſed.

HYDROSTATICS.

SECT. I.

OF THE COMPRESSIBILITY OF WATER.

PROP. I.

An ounce of water when preſſed by a force equal to 14 lbs. is not diminiſhed in bulk one part of 10,000; and therefore water may be conſidered as an incompreſſible fluid; or as only compreſſible in that ſmall proportion.

Cor. The Hydroſtatic laws may be applied to all fluids that are as incompreſſible as water, allowance being made for the difference of their denſities.

SECT. II.

OF THE WEIGHT AND PRESSURE OF WATER.

PROP. I.

Water weighs or gravitates in water, as much as in air, or in vacuo.

PROP. II.

The ſurface of water when at reſt, is parallel to the horizon.

Scholium. This is only true with regard to our ſenſes, and certain quantities of water; for the ſurface of water is either convex or concave in ſmall veſſels; and the ſurface of a drop of water, and of the ocean, is globular.

Cor. Hence the ſurface of water is employed for making planes parallel to the horizon; and, hence the uſe of ſpirit levels.

PROP. III.

All the parts of water preſs each other; and, at the ſame depth, they preſs with the ſame force, in every direction.

PROP. IV.

If water is at reſt in any veſſel, the baſe of which is parallel to the horizon, the preſſure of the water upon the baſe is directly as the baſe and perpendicular height of the water, whatever is the form, and capacity, of the veſſel.

Cor. A ſmall quantity of water may be made to preſs with a force equal to a very great quantity, or to the greateſt weight of any kind.

PROP. V.

Water ſtands at the ſame horizontal height in communicating veſſels, whatever are their forms, or the quantities of water which they contain.

PROP. VI.

The preſſure againſt the baſe of a veſſel, containing water, is as the area of the baſe multiplied by the altitude of the water.

PROP. VII.

The preſſure againſt the ſides of a veſſel, containing water, is as the ſquare of the altitude of the water.

PROP. VIII.

In any lateral plane that ſuſtains water, the centre of preſſure is the ſame as the centre of oſcillation, ſuppoſing the axis of motion to be at the interſection of the plane with the ſurface of the fluid.

Cor. From theſe propoſitions it is eaſy to ſee what ought to be the ſtrength of the bottoms, and ſides of veſſels, containing common water, a cubic foot of which weighs about 76 lbs. troy; and what is the beſt method of ſecuring dam-dykes, and flood-gates.

SECT. III.

OF BODIES IMMERSED IN WATER.

PROP. I.

The preſſure upon a body immerſed in water increaſes in proportion to the height of the water above the body; and the difference of the preſſure upon its upper and under ſurfaces, approaches to equality, as the height is increaſed.

Cor. 1. Hence ſhells, and plants are not broken, though at the bottom of the ocean; and a bottle immerſed in it to a certain depth will break in pieces, or continue entire, according as it is empty, or full.

Cor 2. A veſſel may have a ſtopper made in ſuch a manner as to yield to certain known degrees of preſſure, ſo that when it is immerſed in the ocean the water may be taken up unmixed, from any depth.

PROP. II.

If a body of the ſame ſpecific gravity with water, is immerſed in water, it will remain wherever it is placed. If of greater ſpecific gravity, it will ſink to the bottom. If of leſs ſpecific gravity, it will riſe to the top, and ſwim.

Cor. A hollow body ſpecifically lighter than water, and immerſed in it, may be made to take different altitudes, according as more or leſs water is forced into it, by preſſing the ſurface of the water.

PROP. III.

A body ſpecifically heavier than water, and ſuſpended in it, loſes as much of its weight as a quantity of water weighs that is equal in bulk to the body ſuſpended; and the water gains as much weight as the body loſes.

Cor. If a body ſpecifically lighter than water is kept immerſed in it, the weight of the water will be increaſed as much as the difference between the ſpecific gravity of the body and of the water; and as much as a body of the ſame bulk and ſpecifically heavier would do, if ſuſpended in it.

PROP. IV.

When a body is ſpecifically heavier than water, it will ſink in it with a force that is equal to the exceſs of its own weight above the weight of an equal bulk of water; and, when it is ſpecifically lighter, it will riſe in it with a force that is equal to the exceſs of an equal bulk of water above its own weight.

PROP. V.

A quantity of water equal in bulk to the immerſed part of a body ſwimming on its top, is equal in weight to the whole body.

Cor. 1. The weight of bodies put into a veſſel which floats in water, may be known by the depths to which the veſſel ſinks; and the whole veſſel, with its contents, is to the part immerſed, as the ſpeciſic gravity of the water is to that of the veſſel with its contents.

Cor. 2. A ſhip that is ſunk may be raiſed from the bottom, and brought to the ſhore, if joined by tight cables during a neap tide, to light veſſels that float above her; and, if ſhe is ſunk where there is no tide, by pumping a great quantity of water into the light veſſels before ſhe is joined to them, and then pumping it out.

PROP. VI.

The heavieſt body may be made to ſwim in water, by keeping the water from preſſing upon its upper ſurface; and, the lighteſt body may be made to remain at the bottom, by keeping the water from preſſing upon its under ſurface.

SECT. IV.

OF FINDING THE SPECIFIC GRAVITY OF BODIES.

PROP. I.

If bodies which are compared together are of equal bulks, their abſolute weights will be as their ſpecific gravities. If their ſpecific gravities are equal, their abſolute weights will be as their bulks. And, if their abſolute weights are equal, their bulks will be reciprocally as their ſpecific gravities.

The abſolute weight of any body is as the product got by multiplying its bulk by its ſpecific gravity. The ſpecific gravity is as the quotient of its abſolute weight divided by its bulk. And the bulk is as the quotient of its abſolute weight divided by its ſpecific gravity.

PROP. II.

Pure rain water is the beſt ſtandard fluid; and, when it is uſed in finding the ſpecific gravity of bodies, the following rules ſhould be obſerved.

The temperature of the water and of the body examined ſhould be the ſame, and ſhould be marked. Care ſhould be taken that the body does not imbibe water. Air ſhould be expelled from all its cavities. And the repulſion between it and water, ſhould be overcome by moiſtening it before it is immerſed.

PROP. III.

The ſpecific gravity of fluids may be found by weighing equal bulks of the fluids, and their ſpecific gravities will be as their weights.

By an incurvated glaſs tube, into one leg of which the ſtandard fluid is put, and into the other, the fluid that is examined, with quickſilver interpoſed; and the ſpecific gravity of the fluids will be inverſely as their heights.

By the hydrometer, which, when put into a fluid of greater, or leſs, ſpecific gravity than the ſtandard fluid, will riſe or ſink; the denſities of the fluids compared, being inverſely as the parts immerſed.

By a ſeries of glaſs bubles, increaſing, and decreaſing, in ſpecific gravity from the ſtandard fluid in a known ratio; the one which is of the ſame ſpecific gravity with the fluid that is examined, will remain wherever it is placed.

By the Hydroſtatic balance, from the arm of which a glaſs bubble is ſuſpended in the fluid, that is examined, and weights are put into the ſcale over the bubble, or in the oppoſite ſcale, as the bubble riſes, or ſinks; which weights will give the ſpecific gravity of the fluid, if the weight of the bubble in the air, and in the ſtandard fluid are known.

Of the inaccuracies which are unavoidable in practiſing the firſt four of the above methods.

Of other methods of finding the ſpecific gravity of fluids; and the great inaccuracies to which they are liable in practice.

PROP. IV.

The ſpecific gravity of ſolids may be found by the following methods:

When the body is denſer than the ſtandard fluid,

By ſuſpending it at the arm of a balance, and meaſuring the force with which it deſcends. Or, by weighing it firſt in air, then in the ſtandard fluid, making the difference of the weights a diviſor, the weight of the ſolid a dividend, and the quotient will be the number ſought; that is, if the ſtandard fluid is taken as unity, the quotient will have the ſame proportion to it, which the ſpecific gravity of the ſolid has to that of the fluid.

When the body is not ſo denſe as the ſtandard fluid, its ſpecific gravity may be found:

By immerſing it in the ſtandard fluid, and meaſuring the force with which it aſcends; or, by weighing it in the air, and then in the ſtandard fluid, by placing it in a hydroſtatic bucket with a grate, or by tying it with a horſe hair to a piece of metal to make it ſink, and ſubtracting the weight of the metal in the air and in the water, when a calculation is made in the manner above deſcribed.

PROP. V.

If the ſpecific gravity of two metals is known, and, if a compound, though of the moſt irregular form, is made of them by fuſion, the proportion of the metals in the compound may be thus diſcovered: Find the bulk of the compound, and the bulk of an equal weight of each of the metals; and then, as the difference of the ſpecific gravity of the compound and the lighter metal, is to the difference of the ſpecific gravity of the compound and the heavier metal, ſo is the proportion of their parts in the compound.

Scholium. This method is only exact when the metals in the compound are united by appoſition; for ſometimes the parts of bodies penetrate each other, and their bulks are not preſerved when they are united.

Thus, if gold is mixed with biſmuth, zinc or lead; ſilver with tin, biſmuth, zinc or quickſilver; copper with tin, iron, or zinc; lead with biſmuth, mercury or zinc; and wax with tallow; the bulk of the compound is leſs than it ought to be by the addition of the bulk of the one body to that of the other.

On the contrary, bodies are ſometimes enlarged by mixture. Thus, iron melted with tin, zinc, biſmuth, regulus of antimony, or lead; tin with zinc, biſmuth, lead, or regulus of antimony; and mercury with tin, biſmuth, zinc, or lead; occupy a ſpace that is greater than the bulks of the bodies amounted to, before their union.

PROP. VI.

When the body, the ſpecific gravity of which we would diſcover, is ſoluble in the ſtandard fluid, it may be weighed in air, and then dipped in melted bees wax, in order to prevent its ſolution; and, as white bees wax is of the ſame ſpecific gravity with the ſtandard fluid, there will be no error in the calculation. Or, it may be weighed by the hydroſtatic balance, in a fluid of known ſpecific gravity, that will not diſſolve it; and ſo its denſity, compared to the ſtandard fluid, will be known likewiſe.

PROP. VII.

If great accuracy is required in aſcertaining the ſpecific gravity of a body, the denſity of the atmoſphere ſhould be known; for as it varies, ſo will the weight of the body that is weighed with common weights. Thus, if gold is double the ſpecific gravity of braſs, if maſſes of each are put into oppoſite ſcales, and made of the ſame weight when the atmoſphere is of a certain denſity; and, if they are again weighed when the atmoſphere is not of the ſame denſity; the gold will loſe in weight but one half of what the braſs will loſe; and, conſequently, the former equilibrium will be deſtroyed.

Cor. 1. A buyer of gold will gain by a lighter atmoſphere, and loſe by a heavier; but, the reverſe will take place, if what he buys is ſpecifically lighter than the weights that are uſed.

Cor. 2. If a piece of iron is weighed when its temperature is 50°; and, if it is weighed again, when its temperature is, for inſtance, 400°, its weight will be altered, not only by its expanſion, but by the rarity that is produced in the circumambient atmoſphere by the heat of the iron.

A table of the ſpecific gravity of ſome bodies, when their temperature, and that of the ſtandard fluid is 50°, when the barometer is at 29°½, and, when the balance turns with the fiftieth part of a grain.

Rain water	1,000
Diſtilled water	,993
Salt water, from the mouth of a river	1,030
Salt water, from the ocean	1,680
Aqua fortis	1,300
Aqua regia	1,244
Oil of lintſeed	,942
Oil of ſaſſafraſs	1,099
Alcohol	,742
Spirit of wine	,876
Oporto wine	,993
Burgundy wine	,964
Canary wine	1,043
Diſtilled vinegar	1,011
Cow's milk	1,040
Goat's milk	1,009
Quickſilver, diſtilled	14,000
Quickſilver, from a ſhop	13,500
Sal gem	2,143
Alum	1,714
Nitre	1,900
Amber	1,050

Sulphur	1,800
Diamond	3,400
Agate	2,512
Rock cryſtal	2,659
Iceland cryſtal	2,720
Aſbeſtos	2,943
Granite ſtone	2,460
Chalk	2,470
Talc	2,654
Loadſtone	1,840
Fine gold	19,640
Britiſh ſtandard gold	18,888
Platina, as from the mine	16,995
Parts of platina ſelected	27,500
Platina, cupelled with lead	19,240
Fine ſilver	11,091
Britiſh ſtandard ſilver	10,535
Lead when pure	11,325
Copper	9,000
Tin	7,400
Iron	8,000
Steel	7,704
Oak	,925
Fir	,546
Lignum vitae	1,367
Lignum guiacum	1,337
Cork	,240
Bees wax refined	1,000

Of the differences in tables of ſpecific gravity, which have ariſen from the different denſities of bodies that have the ſame name, and from the different temperature of the ſtandard fluid, or of the bodies that were examined, and from the difference in the conſtruction of the hydroſtatic balances that were uſed.

SECT. V.

OF THE MOTION OF WATER BY ITS OWN PRESSURE.

PROP. I.

If an aperture is made in the baſe of a veſſel that is filled with water, the ſame quantity of it will always flow in a given time, if the veſſel is kept always equally full. But, if there is no ſupply of water to the veſſel, ſo as that it is not always equally full, then the water will flow with a velocity that is conſtantly diminiſhing; and the velocities at given times, will be as the ſquare roots of the altitudes of the water above the aperture.

PROP. II.

When an aperture is made in the ſide of a veſſel, which is filled with water, and which receives no ſupply, the water will flow till its ſurface is in the ſame level with the loweſt part of the aperture; and its velocities will be as the ſquare roots of the altitudes of the water.

Scholium. Theſe propoſitions are only true when no ſenſible retardation is produced by the corpuſcular attraction, the friction of the water, the reſiſtance of the air, or the reſervoir's being ſo ſmall, compared to the aperture, that the preſſure is irregular, or vortices are produced.

SECT. VI.

OF THE QUANTITY OF WATER THAT FLOWS THROUGH APERTURES IN VESSELS.

PROP. I.

Equal apertures being made in a veſſel containing water, the quantities of it that flow in a given time, are as the ſquare roots of the altitudes of the water above the apertures; provided no retardation is produced by the cauſes above mentioned.

PROP. II.

The altitude of water in a veſſel being the ſame, and the apertures different, the quantity that flows, in a given time, is as the apertures; and, if they are circles, in the duplicate ratio of the diameters.

PROP. III.

If cylindric veſſels, containing water, have the ſame heights, and diameters, but unequal apertures, the times in which they are emptied are to each other inverſely as their apertures; and, if they have the ſame heights, and unequal diameters, they are emptied through equal apertures in times that are to each other as their contents.

COR. If apertures are made at heights from the baſe of the veſſel which are as the ſquares of numbers in arithmetical progreſſion, each of the diviſions between the apertures will be emptied in the ſame time.

PROP. IV.

When a cylindric tube is added to the aperture in the baſe of a veſſel, a greater quantity of water flows than when there is no tube, and a ſtill greater quantity flows when the lower end of the tube is enlarged.

A table of the quantity of water which flows in an hour through an aperture of an inch ſquare, when at different depths below the ſurface of the reſervoir; and, of the quantity which flows in an hour through an aperture in the form of a parallelogram, one inch in breadth, and of the length marked in the laſt column; the upper end of the parallelogram being in the ſame plane with the ſurface of the reſervoir.

Quantity from the ſquare aperture.	Quantity from the ſlit aperture.	Depth below the ſurface.
Tons.	Tons.	Inches.
1,04	1,04	1
1,46	2,50	2
1,79	4,29	3
2,08	6,37	4
2,31	8,68	5
2,53	11,21	6
2,74	13,95	7
2,92	16,87	8
3,12	19,19	9
3,28	22,47	10
3,44	25,81	11
3,58	29,39	12
3,74	33,13	13
3,88	36,91	14

Quantity from the ſquare aperture.	Quantity from the ſlit aperture.	Depth below the ſurface.
Tons.	Tons.	Inches.
3,95	40,86	15
4,16	45,02	16
4,28	49,30	17
4,40	53,70	18
4,52	58,22	19
4,62	62,84	20
4,76	67,60	21
4,87	72,47	22
4,94	77,41	23
5,06	82,47	24

Of the quantities of water that flow from reſervoirs with greater heights, and larger apertures.

SECT. VII.

OF SPOUTING WATER.

PROP. I.

A vertical jet does not riſe to the ſame height with the ſurface of the reſervoir, of which theſe are the cauſes. The unequal velocities of the particles, in different parts of the jet, produce a general retardation, as they are all united by corpuſcular attraction. When the higheſt particles ceaſe to have motion, they preſs upon the top of the column. The friction at the aperture diminiſhes its velocity. And, the reſiſtance of the air is a ſtill greater cauſe of retardation.

Cor. The thickneſs of the jet is greater at the ſummit than at the aperture.

PROP. II.

The firſt of theſe cauſes cannot be removed, becauſe it ariſes from the fluidity of the water. The ſecond may be removed by inclining the jet; but this is contrary to the condition of its being vertical. The third may be diminiſhed by a thin ſmooth plate at the aperture, inſtead of a tube. And, the fourth can only be removed when the jet is ſo ſmall as to be placed in vacuo.

PROP. III.

There is a maximum, and a minimum in diminiſhing the above cauſes of retardation. By increaſing the diameter of the aperture, the friction is increaſed only as the diameters, while the momentum is increaſed as the ſquares of the diameters; but, as ſoon as the momentum deſtroys the coheſion of the water, it ceaſes to be a jet. On the other hand, when the momentum is ſo ſmall that the jet cannot act with a certain force againſt the cauſes of retardation, it is broken into little ſtreams, and its altitude is diminiſhed. In order, therefore, to get the greateſt height, and greateſt ſize, of a clear, unbroken column of water, the mean of all the advantages muſt be taken; and it is found by experiments to be as follows:

A table of the heights to which jets, of about an inch in diameter, will riſe, when the reſervoirs are from five, to one hundred feet, in altitude.

Res.	Jet.	Res.	Jet.	Res.	Jet.
5	4.91	7	6.84	9	8.74
6	5.88	8	7.80	10	9.68

Res.	Jet.	Res.	Jet.	Res.	Jet.
11	10.62	41	36.55	71	59.28
12	11.55	42	37.35	72	60.
13	12.48	43	38.14	73	60.71
14	13.40	44	38.93	74	61.42
15	14.31	45	39.75	75	62.13
16	15.22	46	40.53	76	62.84
17	16.13	47	41.31	77	63.54
18	17.03	48	42.09	78	64.24
19	17.93	49	42.87	79	64.94
20	18.82	50	43.65	80	65.64
21	19.70	51	44.42	81	66.33
22	20.58	52	45.19	82	67.02
23	21.46	53	45.96	83	67.71
24	22.33	54	46.72	84	68.40
25	23.20	55	47.48	85	69.08
26	24.06	56	48.24	86	69.76
27	24.92	57	48.99	87	70.47
28	25.78	58	49.74	88	71.14
29	26.63	59	50.49	89	71.81
30	27.48	60	51.24	90	72.48
31	28.32	61	51.99	91	73.15
32	29.16	62	52.73	92	73.82
33	30.	63	53.47	93	74.49
34	30.83	64	54.20	94	75.16
35	31.63	65	54.93	95	75.83
36	32.47	66	55.66	96	76.49
37	33.29	67	56.39	97	77.15
38	34.11	68	57.12	98	77.81
39	34.93	69	57.84	99	78.47
40	35.74	70	58.56	100	79.12

PROP. IV.

If a reſervoir is five feet high, and its conduit-pipe one inch and three fourths in diameter, and not more than one hundred feet in length, it will admit of an ajutage from one fourth to three eighths of an inch in diameter, and ſo on, as in the following table.

Height of the reſervoir.	Diameter of the conduit-pipe.	Diameter of the ajutage.
Feet.	Inches.	Inches.
5	1¾	¼ to ¾
10	2	¼ to ½
15	2¼	½
20	2½	½
25	2¾	½
30	3 to 3½	½ to ¾
40	4¼	¾
50	5	¾
60	5¾ to 6	1
80	6½ to 7	1¼
100	7 to 8	1¼ to 1½

Of the effects of higher reſervoirs, and of larger ajutages, and conduit-pipes.

PROP. V.

Horizontal and oblique jets are ſubject to the ſame cauſes of retardation, as vertical jets, excepting the ſecond; and, the maximum and minimum of their velocities and ſizes are to be determined in the ſame manner. They form a parabola, or part of it; allowance being made for the deviations from that curve, by the above mentioned cauſes.

PROP. VI.

If a ſemicircle is drawn upon the altitude of a reſervoir, as a diameter, and, if a perpendicular is drawn from any point in that ſemicircle to the diameter, twice the length of the perpendicular, will be the amplitude of a horizontal jet, at the point where the perpendicular meets the reſervoir; the amplitude being meaſured upon a horizontal plane paſſing through the baſe of the reſervoir. If th amplitude is not meaſured upon this plane, but upon a plane parallel to it below the baſe of the reſervoir, it will be different, according to the diſtance of the plane from the baſe of the reſervoir, the altitude of the water above the jet, and the properties of the parabola.

Cor. The greateſt amplitude meaſured upon a plane paſſing through the baſe of the reſervoir, is from an aperture made in the centre of the ſemicircle; and, when an aperture is made at the ſame diſtance from the baſe, that another is from the top of the reſervoir, their amplitudes are equal.

PROP. VII.

The amplitudes of an oblique jet, at the ſame angle, are as the ſquare roots of the altitudes of the reſervoir, allowance being made for the retardations above mentioned; and, the amplitudes of oblique jets, from different angles, are according to the laws of projectiles aſcertained in Mechanics.

Of jets produced by forcing machines of different ſorts; and the method of aſcertaining their powers.

SECT. VIII.

OF CONDUCTING WATER IN PIPES.

PROP. I.

Water riſes to the ſame horizontal level in conduit-pipes; but it does not run, unleſs the place of delivery is lower than the reſervoir; and, the velocity with which it runs at different diſtances, below the height of the reſervoir, is in the ſubduplicate ratio of the perpendicular diſtances from a horizontal plane, paſſing through the ſurface of the reſervoir.

Cor. Hence it is requiſite to increaſe the ſtrength of conduit-pipes, according as the preſſure, or the momentum of the water is increaſed.

PROP. II.

Conduit-pipes deliver but a ſmall quantity of water, unleſs they are free'd of the air, which is continually entering with the water; and this is done by cocks and riders of different ſorts.

Of the beſt method of bringing water in conduit-pipes, and of diſtributing it, in towns and houſes.

SECT. IX.

OF NATURAL FOUNTAINS.

PROP. I.

The quantity of water which a fountain yields, in a day, week, month, or year, is meaſured by a fountain gage; and, the quantity of water that falls from the atmoſphere, in the form of rain, hail, ſnow, dew, fog, or vapour, in the ſame time, upon any particular part of the earth, is meaſured by a rain-gage, of which there are various kinds.

Of the rain-gage made in the form of a barometer, from which there is no loſs of water by corpuſcular attraction, or evaporation, and which, with great conveniency, meaſures the water to the thouſandth part of an inch.

PROP. II.

It has been found by experiments, that the fountains in ſome countries yield more water than all the water that falls from the atmoſphere upon theſe countries, in the ſame time.

PROP. III.

Fountains cannot be ſupplied from the ocean, either by preſſure or corpuſcular attraction, according to the hypotheſes of ſome theoriſts.

PROP. IV.

In general, the water that comes from the atmoſphere in all its different forms affords a ſufficient ſupply to the fountains of ſome countries; but, in other countries, they ſeem to receive part of their ſupplies by ſubterranean ſtratums, which reach to a great diſtance; on which account it becomes very difficult to compare the produce of fountains to that of the atmoſphere, in ſmall diſtricts.

PROP. V.

From the obſervations that have been made upon fountains, in different parts of the earth, they may be all divided into three kinds: The common, which are either temporary, or perennial; the intermitting; and the reciprocating: of which diverſity, the cauſes may be explained by the laws of hydroſtatics; and the ſtrata of the earth.

Of pit-wells; and the beſt method of making, and preſerving them, in perfection.

SECT. X.

OF RIVERS.

Of the diviſion of rivers into regular, and irregular, natural, and artificial.

PROP. I.

In a regular river, the particles of water are equably accelerated, as they move upon an inclined plane, from the reſervoir, or ſource; and, in the ratio of the ſquares of perpendiculars, drawn from the river to a horizontal plane paſſing through the ſurface of the reſervoir; allowance being made for the diminution of the celerity by the friction of the water.

Cor. The lower part of the water will move faſter than the upper; and the celerity of the lower and upper parts will approach to equality, as the river goes on.

Scholium. The water will run for a little way in the bed of a river, though parallel to the horizon, by the velocity which it has acquired in coming down an inclined plane.

PROP. II.

The water of a regular river is diminiſhed in depth, as it recedes from the ſource; but while it is in a permanent ſtate, the ſame quantity of water flows in the ſame time through every ſection of it.

PROP. III.

If an obſtacle is placed acroſs the baſe of a river, ſo as to make a cataract, the celerity of the river is not increaſed by the ſtagnant water above the cataract, till it riſes above the upper ſurface of the obſtacle; and then its velocity may be meaſured as in Prop. 1.

Of the cauſes which produce natural rivers; of their windings; of their contrary directions, though they riſe from the ſame hills; and, of the unequal breadth, and depth of the ſame river, in its progreſs to another river, or to the ſea.

Of lakes; ſome of which have outlets, and ſome have none.

PROP. IV.

The inequalities in the beds and ſides of rivers, their windings, the mud, and ſand carried along by the water, are impediments to the accelerating cauſe which gives motion to them; ſo that when theſe impediments become equal to that cauſe, the water will run with an equable celerity.

PROP. V.

The velocity of a river may be accelerated by a greater declivity in its bed, or by additional water that runs into it, or by the diſtance between the banks becoming leſs.

PROP. VI.

There is a corroſion, or the mud and ſand, in the bed and banks of a river, are carried along by the river, as ſoon as its momentum is greater than their coheſion and weight; and they are depoſited as ſoon as it is leſs.

PROP. VII.

In a regular river, the greateſt corroſion is in the middle of its bed or channel; and, in an irregular river, immediately below its thread or ſtream.

PROP. VIII.

Mud, ſand, ſtones, trees, wrecks, produce ſand-beds, ſhallows, and iſlands in rivers; and the ſame cauſes, with land-floods, tides, and accumulations of ice, produce great changes, in their mouths, banks, and ſhoals.

PROP. IX.

An explanation of the methods of defending the beds, and banks of rivers againſt corroſions and inundations; of rendering rivers navigable, by jettees, banks, and locks; and, of the advantages of canals by the ſides of rivers, where theſe methods cannot be uſed.

Of inland navigations by canals, and by locks.

SECT. XI.

OF WAVES AND BILLOWS.

PROP. I.

An unequal preſſure upon the ſurface of water, whether by ſolids or fluids, produces undulations; and they are propogated, from the place of unequal preſſure, in concentric circles.

PROP. II.

If a wave meets with a perpendicular obſtacle, which it cannot overcome, it is reflected in the ſame form with that which it would have had, if it had advanced beyond the obſtacle. If the obſtacle is inclined to the horizon, the reflection of the wave is diſturbed, and often wholly deſtroyed. If there is an aperture in the obſtacle, a new wave is formed, which moves in a circle, of which that aperture is the centre.

PROP. III.

Different waves may be propagated in the ſame water, and at the ſame time, with different directions, and intervals.

Cor. Hence in the ocean, waves are formed upon billows, by guſts of wind; and waves and billows meet each other.

PROP. IV.

A wave moves through its whole breadth in the time of one oſcillation of a pendulum that is equal in length to that breadth. And the celerities of regular waves are as the ſquare roots of their breadths.

SECT. XII.

OF THE TIDES AND CURRENTS.

Facts concerning the tides; with the cauſes of them, which are explained by machines.

PROP. I.

In the great ocean, there are, every twenty four hours, two tides of flood, and two of ebb, ſucceeding each other alternately, at the interval of about ſix hours.

The riſing, and ſinking of the ocean is the effect of three cauſes. The power of gravity in the moon acting upon the earth; the hydroſtatic law, by which water riſes where its preſſure is leaſt; and the diurnal motion of the earth. See Aſtronomy.

PROP. II.

The tides are not higheſt when the moon is in the meridian of a place, but, about three hours afterwards.

Though the moon acts with the greateſt force when in the meridian, yet ſhe is conſtantly adding to that force, for ſome time afterwards; and time is requiſite for the water to move.

PROP. III.

In the ſame place, the tides are near an hour later every day.

The moon is that much later every day in coming to the meridian.

PROP. IV.

There are high, or ſpring tides, when the ſun and moon are in conjunction; and low, or neap tides, when they are in oppoſition; and the greateſt of theſe are not commonly at the equinoxes, but in February, and October.

At the conjunctions, the moon's attraction is increaſed by that of the ſun; and at the oppoſitions, it is diminiſhed.

As the ſun is neareſt the earth in December, his attraction is then greateſt; and therefore he accelerates the vernal high tides; and, as he is fartheſt from the earth in June, his attraction is then weakeſt; and therefore he retards the autumnal high tides.

PROP. V.

The tides do not anſwer exactly to the ſame diſtance of the moon from the meridian, but come on ſooner when ſhe is in the firſt and third quarters; and later, when ſhe is in the ſecond and fourth quarters.

At theſe times, the poſition of the ſun is ſuch that he accelerates, or he retards them.

PROP. VI.

When the moon is in the equator, the tides are equally high in both parts of the lunar day; but, as ſhe declines to either pole, they are alternately higher, or lower, at places which have north, or ſouth latitudes; and, when both tides are equally high in the ſame day, they are at intervals of time which are not exactly equal.

The higheſt tide under the moon, follows her towards the neareſt pole; and the loweſt tide declines towards the oppoſite pole; the other phenomena being explicable by the laws of attraction, and fluidity.

PROP. VII.

In narrow ſeas, and among lands, there are tides at all diſtances of the moon from the meridian; and, in ſome places, the tides among lands, are ſo very irregular, that there is but one tide in a whole day.

The tides are regular upon the open coaſt of the great ocean; and are only rendered irregular by capes, ſhoals, ſtraits, and the windings of friths;

which irregularities are all explicable by the laws of Hydroſtatics.

PROP. VIII.

In ſome rivers, the tides up the country riſe higher than at their mouths; and the flowing and ebbing in them, is at unequal intervals; as for inſtance, five hours and ſeven hours, inſtead of ſix hours, and ſix hours, ſucceeding each other regularly.

There are ſome rivers, in which the tide of flood has not room to ſpread out, as at their mouths; and therefore it muſt increaſe in depth, while at the ſame time, an addition is made to that depth by the freſh water. When the river water is kept up by the flood tide, more time than the ſix hours is requiſite for both to run off, they being likewiſe retarded by the next advancing flood from the ocean.

PROP. IX.

It is not obſerved that there are tides in lakes, though the ſpecific gravity of freſh water is leſs than that of the ocean.

There is not a ſufficient extent of water in them, to make a ſenſible difference in the gravity of their remoteſt parts. The irregular additions of water which they receive from the atmoſphere, and from rivers; and the irregular quantities of it carried off by evaporation, together with the irregular effects of the winds, hinder ſmall tides from being obſerved, ſuppoſing they actually exiſt.

PROP. X.

There are no regular tides in the Mediterranean, though it is about forty degrees in length, and, at a medium, about four in breadth.

The quantity of water carried off by evaporation from this ſea, is much greater than what it receives from the atmoſphere, and from all the rivers that run into it. Its depth, therefore, is conſtantly affected by theſe three things, which, acting irregularly, are diſturbing cauſes; and the water which is carried off by evaporation, is ſupplied by an uninterrupted current from the Atlantic, through the Straits of Gibraltar.

PROP. XI.

There are regular currents in lakes which have outlets, by the motion of the water towards them; and in lakes with promontories, by the eddies which obſtacles produce. And there are irregular currents, by the water's running off, when accumulated on the ſhore by a ſtrong wind.

Similar currents are obſerved in the ocean, which are produced by ſtraits, and capes, and by the winds accumulating the water upon the coaſt; as for inſtance, along the coaſt of America, northward, and eaſtward; which is the effect of the trade winds blowing into the Gulf of Mexico.

SECT. XIII.

OF THE MOTION OF SOLIDS IN WATER.

PROP. I.

The reſiſtance to a ſolid body moving in water, excluſive of its weight, ariſes from the coheſion, and friction of the water, and the quantity of it that is put in motion. The firſt is directly as the corpuſcular attraction; the ſecond as the velocity; and the third as the ſquare of the velocity, at a medium.

PROP. II.

When a globe is moved in water, the reſiſtance is the ſame, whatever poſition is given to it; and the reſiſtance to homogeneous globes is in the compound ratio of the ſquares, and the cubes of their diameters.

PROP. III.

The reſiſtance to a globe, and to a right cylinder moving lengthwiſe, is as two to three, if their diameters are equal.

PROP. IV.

If cylinders are moved lengthwiſe, the reſiſtance is in the reciprocal ratio of their lengths, and diameters.

PROP. V.

The reſiſtance to a globe is to that of a right cone, as two thirds of a line drawn on the ſurface of the cone to a point of the baſe, is to the ſemidiameter of the baſe; if the diameters of the globe, and of the baſe of the cone are equal; and if the cone is moved in the direction of its axis.

PROP. VI.

When a right priſm is moved in a direction perpendicular to its baſe, the reſiſtance is equal to the weight of a column of the water; the baſe of which is equal to the baſe of the priſm, and the height is that from which if a body falls in vacuo, it will acquire the velocity of the priſm.

PROP. VII.

If a priſm is moved in a poſition like that of a wedge, in Mechanics, the reſiſtance is nearly as the baſe of the wedge to the ſum of its ſides.

Of the reſiſtance to ſolid bodies of other forms.

Of the retardations to bodies when in motion in water, with different velocities, forms, and quantities of matter.

SECT. XIV.

OF HYDROSTATIC MACHINES.

PROP. I.

The ſcrew of Archimedes, the Perſian wheel, the wheel with moveable buckets, the lever with a tumbling cone, and Francini's chain-buckets, explained by working models.

PROP. II.

Water mills explained by working models, with underſhot, overſhot, and breaſt wheels, both ſimple, and compound.

PROP. III.

The height of the water acting upon an overſhot wheel being the ſame, the effect is nearly as the quantity of the water that is expended in a given time.

PROP. IV.

When the quantity of water expended in a given time is the ſame, the effect is nearly as the ſquare of its velocity.

Scholium. If the water runs through an aperture in the ſame ſection, but with different velocities, the quantity is proportional to the velocity; and, if the quantity is not proportional to the velocity, the ſection is not the ſame.

PROP. V.

The general ratio of the power to the effect, when greateſt, is as three to one; or, a wheel does the moſt work, when its velocity is equal to one third of the velocity of the water that drives it.

PROP. VI.

If the quantity, and the fall of the water upon an overſhot wheel are the ſame as upon an underſhot wheel of the ſame conſtruction, the effect of the overſhot wheel is double that of the under ſhot wheel, at a medium.

PROP. VII.

When a breaſt wheel is ſimple, or is moved by the gravity of the water alone, the power is to be eſtimated by the weight of the water contained in the buckets, by the time of its retention, and by the diſtance of the centre of gravity of the water in the buckets from the centre of the wheel, as meaſured by perpendiculars drawn from the centre of gravity of the water in the buckets, to a horizontal plane paſſing through the centre of the wheel.

PROP. VIII.

If a breaſt wheel is moved both by the gravity, and by the momentum of the water, the effect is the ſame as that of an underſhot wheel with a head of water, equal to the difference of the level between the ſurface of the reſervoir and the point where the water ſtrikes the wheel, added to that of an overſhot wheel with a height equal to the difference of the level between the point where the water ſtrikes the wheel, and the level of the water that runs below it.

PROP. IX.

The velocity of the circumference of a wheel that works with moſt advantage is three feet in a ſecond of time; this, in practice, being found to be the beſt medium velocity for wheels of all ſizes. Large wheels admit of deviations from this rule with leſs diſadvantage than ſmall wheels.

Of the head, and the effective head, of the water by which wheels are turned. Of the method of regulating the hopper, the diſtance of the mill-ſtones from each other, and the velocity of the upper millſtone, which ſhould not exceed ſixty revolutions in a minute.

PROP. X.

A working model of a mill, which, beſide grinding the corn, performs the work that was formerly done by the ſtrength of men.

Of other mills with wheels moved by water, for working pumps, ſawing wood, and many other uſes.

PROP. XI.

A corn mill without a wheel, with the centrifugal motion of water for its power, explained by a working model.

PROP. XII.

The beſt form of a veſſel that is moved through water, aſcertained by experiments; according as the water is ſhallow, deep, ſmooth, or rough; and according as a ſwift motion, a great lading, or both are required; and, according to the ſpecific gravity of the lading, and the manner of placing it.

PNEUMATICS.

SECT. I.

OF THE ATMOSPHERE.

PROP. I.

The atmoſphere reaches beyond the tops of the higheſt mountains, and to the deepeſt pits. Every maſs of it is a fluid body, and it is not rendered ſolid by cold. In all parts of the earth, it is neceſſary to combuſtion, to vegetation, and to animal life; and, when a maſs of it is divided into four equal parts, one of them is pure air, and the remainder is mephitic; as ſhown in Somatiology, page 32.

SECT. II.

OF THE GRAVITY OF THE ATMOSPHERE.

PROP. I.

By the tube of Torricelli, by the tube of Paſchal, by the ſphere of Otto Guerick, and by many other experiments, it is proved that the air is heavy, or is ſubject to the power of gravity.

PROP. II.

A bulk of air that is equal to an Engliſh quart, when taken near the level of the ſea, and when its temperature is 50°, weighs, at a medium, about 16 grains; and the ſame bulk of rain-water, at the ſame level and temperature, weighs about 14,621 grains.

Cor. Rain-water is about 914 times ſpecifically heavier than air, when taken near the level of the ſea, and when its heat is 50°.

PROP. III.

The preſſure of the air upon every ſquare inch near the level of the ſea is equal, at a medium, to about 15 lbs. troy; and this preſſure is the ſame in every direction.

Cor. 1. The ſlendereſt bodies are not broken, when the preſſure of the air upon all their parts is equal. But many bodies, which can bear a preſſure that is equal to ſeveral pounds, are eaſily broken, when the preſſure of the air upon their ſides is unequal, and when they are not formed like an arch.

Cor. 2. If the ſurface of a middle ſized man is about 14 ſquare feet, he ſuſtains, at the level of the ſea, a weight of air that is equal, at a medium, to about 30,240 lbs. troy; or, 24,882½ lbs. avoirdupois nearly, or 1777 ſtones and 4½ lbs. or, 11 tons, 2 cwt. and 18½ lbs.

Cor. 3. A ſquare mile contains 27′,878,400 ſquare feet. The earth's ſurface, in round numbers, is 200′,000,000 ſquare miles; and therefore, the preſſure of the whole atmoſphere upon the whole ſurface of the earth, is 12‴,043,468″,800,000′,000,000 lbs.

Cor. 4. Bodies that are equally preſſed on all ſides by the air, may be eaſily moved through it with a ſmall velocity. But when the velocity is ſuch, that the preſſure is not the ſame upon every ſide, becauſe the air muſt have time to move, a retardation enſues, as in the motion of race horſes, and military projectiles.

PROP. IV.

When the tube of Torricelli is placed at different heights and depths from the level of the ſea, the column of mercury has different altitudes above the ſurface of the mercury in the baſon; and when the ſame bulk of air, with the ſame temperature, is taken from the atmoſphere, at different heights, and depths from the level of the ſea, it has different weights or ſpecific gravities. By theſe experiments it is proved that if the height of places above, and the depth of places below the ſtandard level, are taken in arithmetical proportion, the denſity of the air is in geometrical proportion.

Cor. 1. The depth, and height of places may be known by the tubes of Torricelli, and Paſchal.

Cor. 2. The force requiſite to ſeparate the hemiſpheres of Otto Guerick, and the weight of the air upon the body of a man, are different, according to the above law.

Cor. 3. If the weight of the air decreaſes in the ſame ratio beyond the higheſt mountain, then, at the diſtance of 7, 14, 21, 28, 35, 42, 49, 56 miles from the ſtandard level, its ſpecific gravity is diminiſhed in the ratio of the following numbers, 4, 16, 64, 256, 1024, 4096, 16384, 65536.

PROP. V.

At the ſame diſtance from the ſtandard level the weight of the atmoſphere changes often, and irregularly. Near the ſtandard level, the height of the mercury in the Torricellian tube, from its baſon, varies from 27 to 32 inches; or through a ſcale of four inches.

COR. 1. Variations in the preſſure of the air upon all bodies may be meaſured by the height of the mercury in the tube of Torricelli.

COR. 2. The preſſure upon the body of a man, near the ſtandard level, is 3000 lbs. leſs at one time, than at another.

Of the effect of this unequal preſſure upon the health, and activity of animals.

SECT. III.

OF THE ELASTICITY OF THE ATMOSPHERE.

PROP. I.

Every part of the atmoſphere is an elaſtic fluid, and its elaſtic force is ſo great, that a ſmall quantity of air, ſuch as two cubic inches, can ſuſtain the mercury in the Torricellian tube to nearly as great a height as the whole weight of the atmoſphere at the ſame level.

PROP. II.

The elaſticity of the air is directly as the compreſſing force, and reciprocally as the ſpace occupied: that is, the ſpace is diminiſhed in the ſame proportion in which the force is increaſed; and increaſed in the ſame proportion in which it is diminiſhed.

PROP. III.

Fire increaſes the elaſticity of the air, and in the direct ratio of the heat; but it is not certain that its elaſticity has the ſame law in every temperature.

SECT. IV.

OF THE UNDULATIONS OF THE ATMOSPHERE.

PROP. I.

When the equilibrium of the air is deſtroyed by the ſudden impulſe of a ſolid, or of a fluid body, or by a ſudden increaſe of its own elaſticity, concentric undulations are propagated in all directions.

PROP. II.

Theſe undulations are ſtrongeſt at the centre of impulſe, or where they are generated. When they meet with no obſtacle, the reſiſtance, and friction of the atmoſphere gradually diminiſh them, till they become inſenſible. When they meet with an obſtacle, they are returned in a manner ſimilar to the undulations of water.

PROP. III.

When an impulſe is given to air through a tube, it reaches to a greater diſtance, and its momentum is greater, than if it had not been confined in that tube. When it leaves the tube, it is propagated from the extremity of the tube, in concentric undulations.

PROP. IV.

If air is forced out of a cloſe veſſel, its velocities and momentums are according to the capacity of the veſſel, the force impreſſed, and the ſize of the apertures.

SECT. V.

OF SOUND.

PROP. I.

The ſenſation of hearing is produced, when an impreſſion is made, by an impulſe, upon the parts of a ſolid body which communicate with the organs of hearing. Thus, the beating of a watch is heard, if a beam is between it and the ear; and the ſtroke of a horſe's foot is heard, if the ground is between it and the ear; when neither could be heard, without the interpoſition of theſe bodies.

PROP. II.

Sound may be excited by an impulſe upon incompreſſible fluids, which communicate with the ear; thus, if hammers are made to ſtrike upon each other below the ſurface of water, the ſtroke may be heard by a man that is immerſed in the water.

PROP. III.

The atmoſphere, by its quick undulations, is the common vehicle of ſound to man, and to land animals: for if a bell is ſtruck in the receiver of an air-pump, the ſound is weak as the air is exhauſted; and loud, as the air is condenſed.

Cor. 1. Sounds are produced by the ſtrokes of ſolid bodies in the air, the quick motions of ſolids through it, the impulſe of the breath, the firing of guns, and by lightning.

Cor. 2. The ſame cauſe produces a greater noiſe at the foot than at the top of a hill; and the ſound in a diving-bell is increaſed as the bell is let down.

PROP. IV.

Sounds are propagated at the rate of 1142 feet in every ſecond of time, or about thirteen miles in a minute; and all ſounds, by whatever cauſe produced, are propagated in nearly the ſame time; but their loudneſs varies according to the denſity, the elaſticity, and the moiſture of the air, and the direction of its currents or winds.

COR. Hence, the depth of mines, the breadth of ſeas, the diſtance of places, and the diſtance of lightning, may be meaſured by ſound.

PROP. V.

When the quick undulations of air meet with obſtacles, they return in a manner ſimilar to thoſe of water, making an allowance for their elaſticity; and they produce echoes, or the repetition of ſounds.

COR. Hence whiſpering galleries, and various methods of forming, and of deſtroying echoes.

SECT. VI.

OF MUSIC.

PROP. I.

An explanation of the ſtructure of the ear; and of the communication of impulſes to its tympanum, by the undulations of the air, and the impulſes of ſolid, and of fluid bodies.

PROP. II.

Muſical tones are produced by the vibrations of elaſtic ſolid bodies, ſuch as muſical ſtrings, bells, and glaſſes, which give undulations to the air that are communicated to the tympanum; and when ſuch bodies loſe their elaſticity, they loſe the power of producing tones.

PROP. III.

The loudneſs of a tone depends upon the momentum of the impulſe or undulation; and the accuteneſs, upon the time in which it is propagated.

PROP. IV.

A muſical chord can be varied in its length, tenſion, and diameter; and as theſe are varied, ſo are the vibrations, and conſequently the tones.

PROP. V.

If muſical chords, of the ſame kind of matter, have equal diameters, and tenſions, the number of vibrations are inverſely as their lengths. If their tenſions, and lengths are equal, their vibrations are directly as their diameters. And, if their diameters and lengths are equal, their vibrations are inverſely as the ſquare roots of their tenſions.

Cor. Hence the method of tuning ſtringed inſtruments, glaſſes, bells, and muſical forks.

PROP. VI.

If the times of vibration of two muſical chords are equal, the tones are uniſons. If the times of vibration are as 1 to 2, the coincidence is at every ſecond vibration of the quickeſt, and the tone is a diapaſon. If they are as 2 to 3, the coincidence is at every third vibration of the quickeſt, and the tone is a diapente. If they are as 3 to 4, the coincidence is at every fourth vibration of the quickeſt, and the tone is a diateſſaron. If the vibrations are carried on in ſimilar proportions, ſimilar tones are produced, but they are imperfect concords; the ſeven natural notes, with their ſemitones, being the elements of muſic, and forming the whole of the diatonic ſcale.

Of melody, and harmony, and of the different parts in muſic.

PROP. VII.

If two monochords, in the ſame room, are uniſons, if the one is ſtruck, the other will vibrate by the undulations of the air, which are produced by the vibrations of the one that is ſtruck. When the one vibrates twice while the other vibrates once, if the firſt is ſtruck, the ſecond will vibrate like two ſtrings of half the length of the firſt, a point of reſt being in the middle. When the one vibrates thrice, while the other vibrates once, if the firſt is ſtruck, the ſecond will have two points of reſt; that is, it will be divided into three equal parts, which will vibrate like three chords of theſe lengths.

Cor. Hence the muſic of Eolus's harp; the tremors produced in animate, and inanimate bodies by tones; and the breaking of ſome bodies, when the tones are uniſons with the bodies, and ſo ſtrong that the vibrations which they produce overcome the corpuſcular attraction of the bodies.

PROP. VIII.

If a maſs of air is impelled againſt any part of the atmoſphere, in ſuch a manner as to produce quick undulations, like thoſe above deſcribed, the effects are the ſame.

Cor. Hence the organs of ſpeech, and of ſinging, produce their effects; and hence the conſtruction of wind-inſtruments of various ſorts.

PROP. IX.

Muſical tones produce effects upon men in four ways. They excite vibrations in certain parts of the body, which are accompanied with affecting ſenſations. Sentiments, and paſſions give impulſes to the voice, and ſo produce tones, which are the ſymptoms of them; and theſe tones excite correſponding ſentiments, and paſſions in the hearer. Certain tones give pleaſing ſenſations that are entirely different from thoſe of ſentiment and paſſion. And they excite pleaſure, by the relations which coexiſting ſounds bear to each other, when combined, according to the laws of harmony.

Of muſic among the ancients, and moderns; and, the cauſes of its different effects.

SECT. VII.

OF METEORS AND WINDS.

PROP. I.

The cauſes of vapours, dew, clouds, ſleet, ſnow, hail, are ſhown in Somatiology.

PROP. II.

Gleams of light in the atmoſphere, the aurora borealis, ſhot ſtars, lightning, and balls of fire, are explained in Electricity.

PROP. III.

An explanation of the rain-bow, the colours of the clouds, and halos of different kinds, belongs to Optics.

PROP. IV.

Winds, or currents of the atmoſphere, are the effects of heat and cold, and of the earth's rotation upon its axis.

When there is a ſudden, and temporary heat in any place, there is a motion of the ſurrounding atmoſphere to reſtore the equilibrium; that is, the wind blows, from every point of the compaſs, to that place. And when there is a heat, however generated, and of whatever duration, greater than the heat of the air in any particular place, the colder air moves towards the warmer; that is, the wind blows from the cold quarter.

If a coaſt is warmer than the adjoining ſea, the cold air over the ſea moves towards the land, in order to reſtore the equilibrium; and the contrary, if the air over the ſea is warmer than that over the land.

In the tropical iſlands, the land and ſea breezes are owing to the ſame cauſes.

Winds are long in one direction, when a great maſs of the atmoſphere is longer cold than another. Thus, the atmoſphere is colder over the regions of the north than over the Atlantic, and winds blow from the north towards Britain, during the cold of winter. Temporary winds ariſe from the ſame cauſes, whether local, or of great extent, and in all countries.

The trade-winds are produced by the heat of the air between the Tropics, the cold at the polar regions, the rotation of the earth, and the compoſition of motion in the atmoſphere.

Monſoons are the effects of the ſame cauſes, and of the diſturbing inequalities of heat in the ſurrounding regions.

A whirlwind is produced in the ſame manner as a vortex in water.

Hurricanes are vortices in the atmoſphere, occaſioned by the above cauſes, and by the ſhifting of the trade-wines, or monſoons.

PROP. V.

Water-ſpouts are the effects of vortices in the atmoſphere, on the tops of billows; and ſometimes, of watery clouds when agitated by lightning.

SECT. VIII.

OF THE VIVIFYING QUALITY OF THE ATMOSPHERE.

PROP. I.

The quantity of air expired by men varies according to their ſize, exerciſe, health, and the ſtate of the air in which they live; but the medium quantity which a man expires in a minute, may be reckoned about thirty cubic inches; and the quantity expired by other animals may be eſtimated in the ſame manner. See page 34, genus IV.

PROP. II.

In every minute of time, the burning of a common tallow-candle, which weighs four ounces, deprives thirty cubic inches of air of their vivifying quality; and the effect of increaſed combuſtion is in the ſame ratio. See page 34, 35.

PROP. III.

The putrefaction of animal, and vegetable bodies, the effluvia of ſome plants, fermentation, and ſome other proceſſes, natural and artificial, deſtroy the vivifying quality of the atmoſphere.

Cor. 1. From the above facts, it appears that churches, hoſpitals, priſons, ſhips, ſtables, cemeteries, ſlaughter-houſes, ought to be well ventilated; and that the air of large towns, and of ſtagnant water with putreſcent vegetables, is leſs favourable to health than that of ſmall towns, and of places where there are few vegetable, and animal ſubſtances in a putrifying ſtate.

Cor. 2. By the cauſes enumerated in theſe propoſitions, the nature of the atmoſphere would be ſo altered, in a courſe of years, that neither fire nor animals could exiſt, were there not a proviſion for reſtoring its ſalubrity.

PROP. IV.

If a vegetable is placed under a receiver that is filled with mephitic air, whether made ſo by combuſtion, breathing, or putrefaction, it languiſhes for ſome time, and then recovers its vigour; and the act of vegetation renders the air ſalutary. This effect is produced not only by the growing of ſuch vegetables, as mint and roſes, but of ſuch as give an offenſive ſmell, and of ſuch as give no ſmell. Thoſe which have the quickeſt growth render the air ſalutary in the ſhorteſt time, care being taken to remove the rotten leaves, and branches, which always retard the operation.

Cor. Every vegetable, in every part of the earth, is conſtantly ſerving, by its growth, to reſtore ſalubrity to the atmoſphere.

PROP. V.

Mephitic air is rendered ſalutary by agitating it with water, and by evaporation; whether the water is freſh, ſalt, clear, or muddy.

Cor. 1. Hence pure air, as well as mephitic, is often found in ſtagnant water, and in the mud of ponds.

Cor. 2. Vapour, dew, ſleet, hail, rain, the running of rivers, the agitation of lakes, tides, waves, billows, gales, and tempeſts are all conſtantly reſtoring the vivifying quality of the atmoſphere.

Cor. 3. Rainy climates are ſalutary, if the air in them is not charged with putreſcent matter. Heavy rains, high winds, cold, and variable weather, check epidemic diſeaſes.

Of the ſalubrity of the air in different climates, and at different altitudes from the ſtandard level.

SECT. IX.

OF PNEUMATIC MACHINES.

PROP. I.

An explanation of the advantages, and diſadvantages of the different kinds of barometers, to which the following names are given: The Torricellian, the Syphon, the Bottle, the Carteſian, Huygens's, Hook's, the Pulley, the Diagonal, the Rectangular, the Pendent, the Four Tubes, the Marine, Prins's, and De Luc's.

Of the Lever-Torricellian, and other barometers.

PROP. II.

The barometer indicates the weight of the atmoſphere, but is not a certain index to the weather, which does not always depend upon the weight of the atmoſphere, but upon its moiſture, heat, cold, various local circumſtances, and the changes of the moon.

PROP. III.

When barometers are uſed for meaſuring heights, the differences ariſing from the temperature of the air, and the expanſion of the mercury ought to be accurately known. The altitudes of the columns in two barometers, the one at the top and the other at the foot of a hill, being taken at the ſame time, their heat being equal, or reduced to equality, and the common temperature of the atmoſphere being given; if the logarithm of the inches of the upper column is ſubtracted from the logarithm of the inches of the lower column, the difference between the four firſt decimals on the left hand will give the number of the fathoms between the upper and lower columns, and the difference of the two laſt decimals will give the parts of a fathom, which being multiplied by 6 will give the number of feet. As the heights of the column of mercury in the barometer are in geometrical progreſſion, and the correſponding heights of the atmoſphere in arithmetical progreſſion, they form an endleſs ſeries;

and therefore the height of the atmoſphere muſt be calculated from known terms, as from a column of mercury which is 1 line, or $\frac{1}{12}$ of an inch in height, and from a column of mercury which is 324 lines, or 27 inches in height.

Of the mode of eſtimating the temperature of the column of air from its extremities. Of other modes of calculation; and of difficulties which ſtill remain in meaſuring the heights of places with very great accuracy.

PROP. IV.

By the marine barometer, the height of the atmoſphere may be known, notwithſtanding the motion of a ſhip; and by the heat at which water boils, the weight of the atmoſphere may be known, and conſequently the height, and depth of places, from the ſtandard level; a degree of the thermometer, correſponding to half an inch of altitude in the barometer, if great accuracy is not required.

PROP. V.

Hygrometers have been made of ſpunge, vitriolic acid, deal board, cat gut, whip cord, wild oats, cord ſaturated with ſalt, and human hair; but moſt of them have the following imperfections. A common ſcale cannot be adapted to them; and when it can, they ſpoil with time; nor do they indicate the quantity of moiſture which the atmoſphere contains, but only the quantity which is leſs attracted by the air than by the hygrometer.

When Leyden phials, that are exactly alike, are fully charged, and equally expoſed to the air, they ſeem to be accurate hygrometers; becauſe, in a given time, they are diſcharged according to the moiſture in the air; as the attraction between electric matter and water is the ſame, in the ſame circumſtances.

PROP. VI.

The quantity of water that comes from the atmoſphere is meaſured by rain gages, of which there are various ſorts, ſee Hydroſtatics Sect. IX; and the celerity of the wind is meaſured by wind gages, as by Hook's anemoſcope; and by the riſing of water in glaſs tubes.

A ſimple and accurate hygrometer is made by the blowing down of ſmall bodies of the ſame ſize, and unequal weights, from the ſame horizontal plane; or by a pendulum, which riſes according to the force of the wind, and marks the degrees of its riſe, with a pencil.

PROP. VII.

Pneumatic ſyphons, and the different kinds of water pumps, explained by working models.

PROP. VIII.

Jets are made by condenſed, and by rarified air; and an explanation is given of fire engines, or machines for extinguiſhing fires.

PROP. IX.

Cupping glaſſes, the different kinds of air pumps, condenſers, and air guns explained.

Cor. Hence, the effects of the ſucking, and of the reſpiration of animals, and of ſpeaking, and hearing trumpets.

PROP. X.

An explanation of bellows, fanners, and the different kinds of wind mills.

PROP. XI.

Chimnies, and fire places, and the method of conſtructing them to moſt advantage, explained.

PROP. XII.

Various contrivances for carrying off foul air deſcribed, ſuch as funnels, blowing wheels, ventilators, fires, and chimnies.

PROP. XIII.

Eudiometers of many kinds, with an account of their advantages and diſadvantages. See page 37.

PROP. XIV.

Ships of different kinds deſcribed, and the principles of their motion by the action of the air upon them. See page 324.

PROP. XV.

The diving bell with its improvements explained by a model.

PROP. XVI.

A model of the ſea gage, for meaſuring the depth of the ocean, without a line or rope.

Of aeroſtation, or the art of travelling through the atmoſphere, by mechanical means like birds, or by ſuſpenſion by floating bodies.

PROP. XVII.

The air balloon with hot, and with inflammable air explained. The improvements of it that are ſtill wanting. And the uſes to which it may be applied.

OPTICS.

SECT. I.

OF LIGHT AND ITS MOTION.

PROP. I.

When fire is modified in a particular manner, it is called light; and the ſenſation which it excites by entering the eye, is called viſion.

PROP. II.

Light is propagated in ſtraight lines, and is ſo ſubtile, that many rays of it may paſs, at the ſame time, without interrupting each other, through a hole that is only $\frac{1}{20}$ part of an inch in diameter; and the momentum of ten thouſand times that number of rays cannot be meaſured by the niceſt inſtrument.

PROP. III.

If light paſſes through a vacuum, its path is not changed. If it meets a body through which it cannot paſs, it either adheres to it, or is reflected. If it enters a body, it is abſorbed, or refracted, or continues its motion without inflection; it being ſubject like other corpuſcles, to the laws of repulſion and attraction, and to their affinities.

PROP. IV.

The velocity with which light moves is ſo great, that it cannot be meaſured between the tops of the moſt diſtant mountains that are viſible from each other. But it can be meaſured when it moves between ſome of the heavenly bodies; for, by the eclipſes of Jupiter's ſatellites, it appears, that it takes 8 minutes and 13 ſeconds in paſſing over the ſemidiameter of the Earth's orbit; which is at the rate of 170,000 miles in a ſecond of time; and therefore its velocity is 680,000 times greater than that of ſound.

PROP. V.

The quantity, and intenſity of light decreaſes in the reciprocal duplicate ratio of the diſtance from the radiant point.

PROP. VI.

So minute are the particles of light compared to the particles of the ſurfaces of the bodies which act upon them, that all the ſurfaces of ſuch bodies, whatever are their forms, may be reduced, without any ſenſible error, to a plane ſurface, to a ſpherical convex ſurface, and to a ſpherical concave ſurface, with their combinations.

Of a pencil of rays, and how to eſtimate its direction.

SECT. II.

OF THE REFLECTION OF LIGHT.

PROP. I.

When light moves at right angles againſt a plane ſpeculum, it is either abſorbed by it, or it is reflected in the path in which it came. But, if it moves againſt it obliquely, it is reflected in ſuch a manner that the angle of reflection is equal to the angle of incidence; and it is reflected by a repulſive power upon the ſurface of the ſpeculum, and not by having been in contact with the parts of the ſpeculum.

PROP. II.

If a plane ſpeculum, and a radiant object are placed at right angles to the horizon, and, if the object is ſeen by reflection from the ſpeculum, the image is erect, of the ſame ſize with the object, but tranſpoſed, and at the ſame diſtance behind the ſpeculum, that the object is before it.

PROP. III.

When a radiant object is at right angles to a plane ſpeculum that is parallel to the horizon, the image of it, ſeen by an eye placed above the ſpeculum, is perpendicular to the horizon, but inverted.

PROP. IV.

If a plane ſpeculum is at half a right angle to the horizon, and, if a radiant object and an eye are placed below it, the image of the object is ſeen by the eye parallel to the horizon, and above the ſpeculum. If a radiant object is parallel to the horizon over a plane ſpeculum that makes an angle with it of 45°, and, if an eye is between the plane of the object and the ſpeculum, the image of the object is ſeen by the eye behind the ſpeculum and perpendicular to the horizon.

PROP. V.

When two plane ſpeculums form a right angle that is biſected by a ſtraight line, if an eye is placed on one ſide of that ſtraight line and an object on the other ſide, the eye will ſee the image of the object once behind the ſpeculum that is fartheſt from it, and twice behind the ſpeculum that is neareſt to it.

PROP. VI.

If two plane ſpeculums are joined at an acute angle, and if between them there are placed an object and an eye, which are not in the ſame ſtraight line that paſſes through the angle, the object may be ſeen by the eye as often in each of the ſpeculums as perpendiculars can be drawn alternately to the ſpeculums, beginning with the object, till the moſt diſtant perpendicular either ends upon one of the ſpeculums, or within the vertical angle that is formed by the ſpeculums, when produced.

PROP. VII.

When two plane ſpeculums are parallel to each other, and, an eye is placed between them, at the one end, and a radiant object at the other, the eye will ſee images of the object in an endleſs ſeries.

PROP. VIII.

Theſe propoſitions are applicable to thin mirrors, or to thin maſſes of fluid bodies, by which light is reflected. When they are thick, there are reflections from different internal ſurfaces, ſo that the images are increaſed in number, and faintneſs, according to theſe ſurfaces, and the laws of reflection: and this is likewiſe true of mirrors, whatever are their forms.

PROP. IX.

The angles of incidence and reflection are equal from a ſpherical convex ſpeculum; the perpendicular being a ſtraight line, drawn from the centre of the ſpeculum, through the point where the incident ray meets its ſurface. If a ray falls upon the ſpeculum, in the direction of that perpendicular, it is either abſorbed, or reflected in the ſame path.

PROP. X.

If parallel rays are reflected from a ſpherical convex ſpeculum, they diverge, and form an imaginary focus in the middle point between the centre and the ſurface of the ſpeculum.

PROP. XI.

When diverging rays are reflected from a ſpherical convex ſpeculum, the imaginary focus is found by dividing the radius of the ſpeculum into two parts, having the ſame ratio to each other, which the diſtance of the radiant point from the centre has to its diſtance from the ſurface of the ſpeculum.

PROP. XII.

If the image of a radiant object is placed before a ſpherical convex ſpeculum, it is ſeen behind it, and erect; but, it is convex towards the object, and varies in its ſituation and ſize, according to the poſition of the eye, and the convexity of the ſpeculum; and, as the object approaches the ſpeculum, ſo does the image, till they meet.

PROP. XIII.

The angles of incidence and reflection are equal from a ſpherical concave ſpeculum, the perpendicular being a ſtraight line, drawn from the centre of the ſpeculum, through the point where the incident ray meets its ſurface; and, if a ray falls upon the ſpeculum in the direction of that perpendicular, it is either abſorbed, or reflected in the ſame path.

PROP. XIV.

If parallel rays, which are near each other, fall upon a concave ſpherical ſpeculum, one of them paſſing through its centre, they will meet, when reflected, near a point in the one paſſing through the centre, which is equi-diſtant from the ſpeculum and the centre. If a radiant object is placed in that point, its rays, when reflected by the ſpeculum, will be parallel to each other. And, if the object is placed in the centre, the rays will be reflected to the point from which they came, in paths that are the radii of the ſpeculum.

Cor. 1. A focus is formed by parallel rays, which are reflected from a concave ſpeculum; but, if they are not near each other, they will form a ſmall circle round the middle point, between the centre of the ſpeculum and its ſurface.

Cor. 2. Hence a method of throwing light to a great diſtance, and with its rays parallel to each other.

PROP. XV.

When diverging rays, that are near each other, come from a radiant object, that is beyond the centre of the ſpeculum, they meet in a point of that ray which paſſes through the centre of the ſpeculum, and divides the diſtance of the centre from the ſpeculum into two parts, in the ſame ratio to each other, which the diſtance of the object from the ſpeculum has to its diſtance from the centre.

PROP. XVI.

The rays, which, by the laſt propoſition, meet in a point between the centre and the ſpeculum, diverge as they go on from that point, and an eye that receives them will ſee the image of the radiant object in that point, and inverted. If the radiant object is placed in that point, the rays from it, that are reflected by the ſpeculum, meet in the point where it was formerly placed; and the image of the object will be ſeen in that point, and inverted, by an eye that is placed beyond it.

PROP. XVII.

If the radiant object is placed within the fourth part of the diameter of the ſphere of which the ſpeculum is formed, the diſtance of the imaginary focus from the ſpeculum is to its diſtance from the centre, as the diſtance of the object from the ſpeculum is to its diſtance from the centre.

PROP. XVIII.

When a radiant object is placed between the centre and the ſpeculum; and an eye receives the rays from it that are reflected by the ſpeculum, the image is ſeen behind the ſpeculum, and larger than the object.

Of the method of determining the ſize of the image; and of other phenomena, produced by convex, and by concave ſpeculums.

SECT. III.

OF THE REFRACTION OF LIGHT.

PROP. I.

If light falls, at right angles, upon a refracting medium with plane ſurfaces, it is either abſorbed, or goes on in a ſtraight line till it comes to the oppoſite ſurface. If it falls obliquely, and the new medium has a greater refracting power than the former medium, it is inflected towards the perpendicular. If the new medium has a leſs refracting power, it is inflected from the perpendicular. And, in both caſes, there is a conſtant ratio between the angles of incidence, and refraction.

PROP. II.

When a ray comes from air into common water, the angle of incidence is to that of refraction as 4 to 3 nearly; when from air into common glaſs, the angle of incidence is to that of refraction as 17 to 11. But it is different in different kinds of glaſs; and the refracting power is not according to the ſpecific gravity of the glaſs, but according to the elective attraction which it has with light.

PROP. III.

If parallel rays enter a new medium which has a different refracting power, and is bounded by plane parallel ſurfaces, they are parallel, when they leave the medium, whether they were inflected to, or from the perpendicular.

PROP. IV.

When diverging rays, that are near each other, enter a new medium that has a plane ſurface, and with one ray perpendicular to it, their paths may be thus determined. Produce the perpendicular beyond the point from whence the rays diverge; and, as the ſine of the angle of reflection is to the ſine of the angle of incidence, ſo let the diſtance of the ſurface of the medium, from the diverging point in the perpendicular, be to a diſtance beyond that point in the ſame perpendicular, from the ſurface of the medium. And, from that diſtance, if ſtraight lines are drawn to the points in the ſurface of the medium where the diverging rays enter obliquely, theſe ſtraight lines, if produced, will be the paths of the rays when refracted.

Scholium. When diverging rays are far diſtant from each other, their refracted paths, if produced, do not meet in the perpendicular, but in a ſmall circle on one ſide of it.

The place where converging rays meet, may be determined in a ſimilar manner.

PROP. V.

If parallel rays fall upon a differently refracting medium that has a ſpherical convex ſurface, and, if one of the rays paſſes through the centre of that ſurface, that ray will go on in the ſame ſtraight line, and the other rays will meet it in a point which is thus found. From the place where a given ray enters the ſurface, draw a ſtraight line to the central ray within the medium, and, let the length of that ſtraight line, be to the length of the path of the central line between the centre, and where that ſtraight line meets the central line, in the ſame ratio which the ſine of the angle of incidence bears to the ſine of the angle of refraction; and the line ſo determined will be the path of the refracted ray. But, when the parallel rays are near each other, the point of meeting may be thus found: As the ſine of the angle of refraction is to the ſine of the angle of incidence, ſo let the diſtance of the ſurface from the centre be to the diſtance of the ſurface to the point that is ſought.

Scholium. In a ſimilar manner, the paths of parallel rays that fall upon concave ſpherical ſurfaces may be found.

PROP. VI.

When rays that are not much diverging fall upon a ſpherical convex ſurface, their paths when refracted, may be thus found By the former propoſition, find a point that is the focus of parallel rays, after their refraction when coming from the oppoſite medium; and, as the diſtance of the radiant body from that point, is to its diſtance from the centre of the ſpherical ſurface, ſo let the diſtance of the radiant body from that ſurface, be to a point in the central radius when produced within the medium.

Scholium. The laws of the refraction of diverging rays which fall upon a concave ſpherical ſurface may be found in a ſimilar manner.

Of other phenomena relating to the refraction of diverging, and converging rays, which paſs through mediums with different refracting powers, and with different ſurfaces.

PROP. VII.

If parallel rays enter a medium that is a ſphere, and with refracting powers different from thoſe of the circumambient medium; and if one of the rays paſſes through its centre, they will meet in a focus, which is thus determined. Let the ſtraight line, in which a given ray moves after its firſt refraction, be produced till it meets the ray that paſſes through the centre of the ſphere; biſect the diſtance between it and the ſphere, and that will be the focus of the rays.

Of the method of determining the paths of diverging and converging rays, which enter mediums that are ſpheres with refracting powers, different from the circumambient mediums.

PROP. VIII.

If parallel rays enter a lens, that is plano-convex, or, double-convex, or, plano-concave, or, double-concave, or convex-concave; the centre of the lens may be thus determined. In the firſt four, the ſum of the ſemidiameters is to the thickneſs of the lens, as the leaſt ſemidiameter is to the diſtance of the centre from the greateſt curvature; and, in the fifth, the difference of the ſemidiameter is to the thickneſs of the glaſs, as the leaſt ſemidiameter is to the diſtance of the greateſt curvature.

Cor. If a pencil of rays falls perpendicularly on a thin lens, the rays which paſs through the centre of the lens may, without any ſenſible error, be conſidered as moving in a ſtraight line.

PROP. IX.

When parallel rays fall almoſt perpendicularly upon a lens, their focus may be thus determined. Let the centre of the lens, the centres of its ſurfaces, and the axis of the lens be found; let a line parallel to the incident rays upon one of the ſurfaces be drawn, of which the ſemidiameter is parallel to the former line, and in which, when produced, is the focus of the rays refracted by that ſuperficies; then join that focus and the centre of the other ſuperficies by a ſtraight line, and the point ſo determined will be the focus of the rays that paſs through the lens.

Of the paths of incident rays, according as they are parallel to the axis, and according to the thickneſs of the lens.

PROP. X.

If rays diverging from a point that is in, or near, the axis of a lens when produced, fall upon the lens and paſs through its centre, their focus may be thus determined. Let the focus of parallel rays coming from the other ſide of the lens be found, and in the ſame ratio in which that focus divides the diſtance between the radiant point and the centre of the axis, let the line of the axis be divided, when produced on the other ſide, and the moſt diſtant point ſo found, is the focus of the refracted rays.

Of the path of the rays, according as the radiant point is between the focus of the parallel rays, and the lens, or beyond that focus.

PROP. XI.

Plano-convex, and double-convex, lenſes bring rays to a focus; but concave lenſes diſperſe them. When rays are received before they reach the focus, the image of the radiant object is erect, of different ſizes, and more or leſs diſtinct according to its diſtance from the focus. When the rays have paſſed the focus, the image is inverted, of different ſizes, and diſtinctneſs, according to its diſtance from the focus, and other circumſtances.

Of other phenomena produced by lenſes, when they are thick, and the rays are far from the axis.

SECT. IV.

OF THE EYE AND VISION.

PROP. I.

The coats, fluids, nerves, muſcles, and external parts of the eye explained by diſſections.

PROP. II.

An image of a radiant object is formed upon the retina, is inverted, is more or leſs diſtinct according to the diſtance of the object, and varies its place as the object is moved.

PROP. III.

Diſtinctneſs in viſion ariſes from one, or all of the following cauſes. The quantity of light, which varies according to the diſtance, colour, or ſhape of the radiant object. The ſize of the pupil, and the action of the iris. The tranſparency of the humours. And, the ſtate of the coats, muſcles, retina, and optic nerve.

PROP. IV.

The imperfect ſight, that is produced by the ſhrinking of the humours of the eye in old age, is remedied by a double-convex lens; and, the defects of the purblind, by a double-concave lens.

Of other diſeaſes of the eye, and the methods of remedying them.

PROP. V.

In viſion, the judgment of the magnitudes, diſtances, poſitions, and even of the number of bodies, is founded on experience, habit, and collateral circumſtances.

PROP. VI.

Various phenomena in Optics may be explained by the above principles, and by judgments formed in a ſimilar manner by the other external ſenſes.

SECT. V.

OF THE REFRANGIBILITY OF LIGHT.

PROP. I.

Every ray of light conſiſts of ſeven parts, which may be ſeparated by refraction, and which have always the ſame degrees of refrangibility. A ſection of each of theſe ſeven parts, made at right angles to its axis, forms a circle; and all the ſeven parts, when ſeparated according to their different degrees of refrangibility, form an oblong figure, or ſpectrum; the ſides of which are parallel, and the ends circular.

PROP. II.

The firſt of theſe ſeven parts excites the ſimple ſenſation called red; the ſecond, orange; the third, yellow; the fourth, green; the fifth, blue; the ſixth, indigo; and, the ſeventh, violet; the firſt being the leaſt refrangible, and the reſt in the above order.

PROP. III.

None of theſe ſeven parts of a ray can be decompoſed; and they always produce the ſame colours; on which account they are called the primary, or original colours.

PROP. IV.

All the varieties of colours, and their ſhades, may be produced by mixing the ſeven original parts of a ray in various proportions. White is produced by blending them all together; black, by abſorbing or deſtroying them; and, darkneſs, by their abſence.

PROP. V.

If the ſpectrum is well formed, and divided into 360 parts, red conſtantly occupies 45; orange, 27; yellow, 48; green, 60; blue, 60; indigo, 40; and violet, 80. And, there is the ſame proportion between theſe parts of the ſpectrum, and the muſical diviſions of a monochord.

SECT. VI.

OF THE COLOURS OF BODIES.

PROP. I.

The colours of ſolid bodies are produced by the texture of their ſurfaces. They are black, when they abſorb all the rays that fall upon them; white, when they reflect them; and, of the different primary colours, and their ſhades, when they reflect only one of the ſeven parts of a ray, or, the parts of different rays, which conſtitute the ſhades.

Cor. The colours of ſolid bodies are changed by changing their ſurfaces, or by changing their poſitions without changing their ſurfaces. Hence the different colours, which are given to the ſame metal, by the difference of tempering. Hence the effects of paints, and dyes, the different colours of plants in the different times of their growth, the varying colours of the opal, of the pigeon's neck, and of the ſilks called changeable.

PROP. II.

In the ſame manner, fluid bodies have different colours, according to the rays, or parts of rays, which they abſorb, tranſmit, or reflect; and every variety of colours may be produced by mixing fluids together.

Cor. Hence the pellucid ſtream, the green ſea, the white froth, the dark pool, the azure ſky, and clouds with all the varieties of colours, and their ſhades. Hence the different quantities of light that are reflected from water, and from glaſs, according to the poſition of the radiant object. Hence the brightneſs of pure flame, and the many colours it will acquire, by mixing various bodies with it. And, hence the falſe judgments of the colours of bodies which are formed when the coats, or humours of the eye are diſeaſed.

Of the rainbow, perfect and imperfect, exterior and interior. Of the halo, and other phenomena of that kind.

PROP. III.

An artificial rainbow may be formed, if rays of the ſun are made to fall upon drops of water like rain, where they ſuffer one refraction, and, after being hereby thrown upon the back part of the inner ſurfaces, are from thence reflected to the lower part of the drops, where they are again refracted, and ſo inflected as to come directly to the eye.

SECT. VII.

OF OPTICAL INSTRUMENTS.

PROP. I.

Microſcopes, ſimple, compound, and ſolar, explained, and experiments made with them.

PROP. II.

Spectacles, and reading glaſſes of various kinds; with a deſcription of the moſt advantageous manner of uſing them.

PROP. III.

An explanation of the firſt invented teleſcope, with a double-convex object-glaſs, and a double-concave eye-glaſs; of the celeſtial teleſcope, in which both the object, and eye glaſſes are double-convex lenſes; and, of the terreſtrial teleſcope, conſiſting of three glaſſes, all of which are double-convex lenſes.

PROP. IV.

Teleſcopes deſcribed with four, and with ſix double-convex lenſes; and with glaſſes of different magnifying powers, according to the ſtate of the atmoſphere.

PROP. V.

Reflecting teleſcopes explained, according to the invention of Gregory, Newton, and Caſſegrain.

PROP. VI.

The Achromatic, or Dollond's, teleſcope explained by the refraction of rays through different kinds of glaſs, when combined into lenſes.

Of the magnifying powers of microſcopes, and teleſcopes, and the method of computing them.

PROP. VII.

An account of the teleſcopes invented by Dr. Herſchel.

PROP. VIII.

By the focus of concave ſpeculums, and of concave mirrors, the effects may be produced that are enumerated in Somatiology, Sect. XII. Prop. XXXIII. By the reflection of rays from four hundred plane mirrors, each half a foot ſquare, lead has been melted at the diſtance of 140 feet, and wood has been ſet on fire at the diſtance of 300 feet.

PROP. IX.

Experiments made with the camera obſcura of different kinds, the magic lantern, the polemoſcope, and other optical inſtruments, with the principles of their conſtruction.

ASTRONOMY.

SECT. I.

OF THE FACE OF THE HEAVENS.

PROP. I.

When the view of an obſerver is bounded, in all directions, by the ſea, or by a great plane, the heavens appear to him to be a concave hemiſphere, in the centre of which he is placed; and, in clear weather, he ſees the Diurnal Motion of the Heavens, that is, the revolution of the Fixed Stars; of the Planets, Mercury, Venus, Mars, Jupiter, Saturn; of the Moon; and of the Sun; from eaſt to weſt, every twenty-four hours nearly; or in 23 hours, 56′, 4″, in which period no inequality is obſerved.

PROP. II.

The obſerver ſees the Fixed Stars moving in paths which are the arcs of unequal circles, all the centres of which are in one place that has no motion; and which is called the North, or the South, Pole of the Heavens, according to his ſituation.

Of ſimple methods of obſerving the motions of the heavenly bodies; and of finding the Pole Stars.

PROP. III.

The Fixed Stars that are viſible by the naked eye, from different parts of the earth, are about five thouſand; but it is ſeldom that more than one thouſand can be ſeen by a common eye, at the ſame place and time, without the help of glaſſes; and never more, it is ſaid, than about fifteen hundred.

Of the Proper Motion of the Planets, Moon, and Sun.

PROP. IV.

The five Planets are known by their ſteady light, and by the change of their relative places among the Fixed Stars. Mercury is ſeen in the ſame place of the heavens after 87 days, 23 hours; Venus, after 224 days, 17 hours; Mars, after 1 year, 321 days, 23 hours; Jupiter, after 11 years, 317 days; and Saturn, after 29 years, 177 days.

PROP. V.

The Moon is ſeen among the Fixed Stars farther to the eaſt, about 13° every day; ſo that, at the end of 27 days, 7 hours, 43′, ſhe completes 360°, or the whole circuit of the heavens. After ceaſing to be viſible, ſhe appears in the weſt, when the Sun is ſet, with her horns turned from him; and ſhe continues, as before, to go eaſtward, with the well known phaſes called the New Moon, Full Moon, Half Moon, and the Quadratures.

PROP. VI.

The Sun's motion among the Fixed Stars, is known by obſerving thoſe ſtars which appear at midnight; thoſe which appear, and diſappear, at his ſetting and riſing; and thoſe which are ſeen in the day-time by contrivances for keeping his rays from the eye of the obſerver. He is ſeen every day about 1° to the eaſt of his place on the preceding day; ſo that at the end of 365 days, 6 hours, 9′, 11″, he is in the ſame ſidereal place in which he was when the obſervations began.

PROP. VII.

All the paths of the Sun, Moon, and Planets are different; but they are in one zone of the heavens, called the Zodiac, which is in breadth about 17°.

Of the Zodiacal Light, and Galaxy.

SECT. II.

OF THE ARTIFICIAL DIVISIONS OF THE HEAVENS.

PROP. I.

The Fixed Stars are divided into Groups, or Conſtellations, to which various names have been given in different countries. They are formed into one hundred Conſtellations; and every Star, in each of them, is accurately marked in aſtronomical tables, and named by ſome of the letters of the alphabet.

PROP. II.

In the Zodiac there are twelve Conſtellations, to wit, Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, Piſces.

Of the reaſons aſſigned for the fanciful names that have been given to the heavenly bodies; and of Judicial Aſtrology.

PROP. III.

There are twenty-three Northern Conſtellations, to wit, Urſa major, Urſa minor, Draco, Cepheus, Caſſiopea, Andromeda, Perſeus, Pegaſus, Equulus, Triangulum, Auriga, Coma Berenices, Bootes, Corona Septentrionalis.

Ophiucus, Serpens, Hercules, Aquila, Antinous, Sagitta, Lyra, Cygnus, Delphinus.

PROP. IV.

There are ſixty-five Southern Conſtellations, to wit, Orion, Balaena, Eridanus, Lepus, Canis, Canicula, Hydra, Crater, Corvus, Centaurus, Lupus, Ara, Piſcis, Navis, Corona Auſtralis.

Camelopardus, Jordanes, Tigris, Sceptrum, Columba, Monoceros, Crux, Sextans, Rhombus, Aſterion et Chara, Leo minor, Lynx, Vulpes, Anſer, Scutum Sobieſki, Triangulum Parvum, Cerberus, Ramus, Stellio, Mons Menali, Cor Caroli, Robur Carolinum.

Indus, Grus, Phoenix, Muſca, Triangulum Auſtrale, Avis Paradiſi, Pavo, Toucan, Hydrus, Dorado, Piſcis Volans, Chamaeleon, Nubes, Nubecula.

Officina Sculptorum, Fornax Chymica, Horologium, Reticulum, Burina, Coma Pictoris, Pyxis Nautica, Antlia Pneumatica, Octans, Circinus, Norma, Teleſcopium, Microſcopium, Trapezophorum.

Of the Fixed Stars called Informes, Nebuloſae, Mutabiles, and Novae.

PROP. V.

The Fixed Stars, when taken individually, are divided into ſix claſſes, according to the degrees of their luſtre. The brighteſt are reckoned of the firſt magnitude; the next in brightneſs of the ſecond;

and ſo on, to thoſe of the ſixth, which are ſuch as are juſt viſible by the naked eye in a clear, dark night. There are commonly reckoned but fifteen of the firſt magnitude, Aldebaran, Regulus, Spica Virginis, Antares, Sirius, Humerus Orionis, Rigel, Capra, Lyra, Arcturus, Procyon, Cor Hydrae, Fomahant, Canopus, Acharnar. The firſt four are all that are in the twelve Conſtellations, and the two laſt cannot be ſeen in Europe. The three ſtars in Orion's belt are of the ſecond magnitude.

PROP. VI.

There are imaginary Circles in the heavens correſponding to thoſe in the earth, to wit, the Horizon, which is ſenſible or rational, the Meridian, the Equinoctial, the Ecliptic, the Tropic of Cancer, the Tropic of Capricorn, the Artic and Antartic Circles.

PROP. VII.

In the ſame manner, there are correſponding Points in the heavens, to wit, the North Pole, the South Pole, the Zenith, the Nadir, the four Cardinal Points, the two Solſtitial Points, the Poles of the Ecliptic.

PROP. VIII.

The Method of knowing the Stars, and the imaginary Points, and Circles, is ſhewn by viewing the heavens.

Of the Right Aſcenſions, Declinations, Longitudes, and Latitudes of the Heavenly Bodies.

Of the Culmination, and Heliacal Riſing, and Setting of the Stars.

Of the Parallax of the Sun, Moon, and Planets.

Of their Tropical, Sidereal, and Synodical Revolutions.

SECT. III.

OF ASTRONOMICAL INSTRUMENTS.

PROP. I.

A deſcription of the earth and heavens, by globes, an armillary ſphere, planetarium, and orrery. See Mechanics, Sect. XXI.

PROP. II.

It is ſhewn, how the altitudes, paſſages, and motions of the heavenly bodies are accurately meaſured by quadrants, tranſit inſtruments, and ſextants.

PROP. III.

How the diſcs, phaſes, bulks, and diſtances, of the Sun, Moon, and Planets, are aſcertained by micrometers, trigonometrical inſtruments, and calculations.

PROP. IV.

A model of an Aſtronomical Obſervatory is deſcribed, and the apparatus which is neceſſary for accurate obſervations.

PROP. V.

Aſtronomical Inſtruments for travellers, and mariners are explained.

SECT. IV.

OF THE PERIODS, BULKS, DISTANCES, ORBITS, &C. OF THE SUN, MOON, AND PLANETS.

PROP. I.

Sun, Moon, and Planets.	Tropical Revolutions.					Sidereal Revolutions.					Synodical Revolutions.			
	Years.	Days.	Hours.	Min.	Sec.	Years.	Days.	Hours.	Min.	Sec.	Days.	Hours.	Min.	Sec.
The Sun,	1	0	5	48	45,5	1	0	6	9	11,2				
The Moon,	0	27	7	43	4,6	0	27	7	43	11,5	29	12	44	3
Mercury,	0	87	23	14	25,9	0	87	23	15	37,	115	21	3	22
Venus,	0	224	16	41	32,4	0	224	16	49	12,7	583	22	7	6
Mars,	1	321	22	18	27,3	1	321	23	30	43,3	779	22	28	26
Jupiter,	11	315	8	58	27,3	11	317	8	51	25,6	398	21	15	45
Saturn,	29	164	7	21	50,	29	176	14	36	42,5	378	2	8	8

PROP. II.

Sun, Moon, and Planets.	Diam. in Min. & Sec.	Diam. in Leagues.	Diameters compared to the Earth.	Relative Numbers.
The Sun,	31′ 57″,5	323155	One hundred and 13 diam. of the Earth, or,	112,79
The Moon,	4,642	782	One-fourth, or $\frac{3}{11}$ of the diam. of the Earth,	0,273
Mercury,	7,	1180	Two-fifths,	0,41176
Venus,	16,52	2785	Leſs by a thirty-third part,	0,97196
The Earth,	17,	2865	The Standard of Compariſon	1,
Mars,	11,4	1921	Two-thirds, or,	0,67059
Jupiter,	3 13,7	32644	Eleven diameters and one-third,	11,393
Saturn,	2 51,7	28936	Ten diameters,	10,1

PROP. III.

Sun, Moon, and Planets.	Bulk compared to the Earth, in round numbers.	Comparative bulks more exactly.	Denſity compared to the Earth.
The Sun,	Fourteen hundred thouſand times greater,	1435025	0,25463
The Moon,	The forty-ninth part of the Earth,	0,02036	0,68706
Mercury,	The ſeven hundredth part of the Earth,	0,06981	2,0377
Venus,	Eleven-twelfths of the Earth,	0,91822	1,275
The Earth,	The Standard of Compariſon,	1,	1,
Mars,	Three-tenths of the Earth,	0,30155	0,72917
Jupiter,	Fourteen hundred and ſeventy times greater,	1479	0,22984
Saturn,	One thouſand and thirty times greater,	1030	0,1045

PROP. IV.

Sun, Moon, and Planets.	Quantities of Matter.	Power of Gravity at the ſurface.	Mean diſtances in leagues.
The Sun,	365412	433,81	34761680
The Moon,	0,01399	2,83	86324
Mercury,	0,14228	12,673	13456204
Venus,	1,1707	18,717	25144250
The Earth,	1,	15,1038	
Mars,	0,21988	7,39	52966122
Jupiter,	340,	39,55	180794791
Saturn,	106,9	15,83	331604504

The quantities of matter are compared to the quantity of matter in the Earth. The power of gravity is ſuppoſed to extend through the ſyſtem; and its force to be meaſured by the fall of bodies in a ſecond; 15,1038 F. or 16 B. feet, being a ſpace through which a body falls in that time upon the the Earth. See Gravitation, Sect. I. Prop. IV. Mechanics, Sect. V. Prop. VI. The mean diſtances of the Sun, the Moon, Mars, Jupiter, and Saturn, are with regard to the Earth: the mean diſtances of Mercury and Venus are with regard to the Sun; for, compared to the Earth, they are nearly the ſame as the diſtance of the Sun from the Earth, or 34761680 leagues. The uncertainty of the diſtance of the Moon from the Earth is not 50 leagues in 86000 leagues: the uncertainty of the diſtance of the Sun and Planets from the Earth is about one part in 200000 parts of the whole diſtance, which amounts, perhaps, to 200000 leagues for the Sun.

PROP. V.

The orbits of the Sun, Moon, and Planets are ellipſes; and, if a ſtraight line is drawn from the moving body to the focus of the ellipſe, the areas deſcribed by that line are proportional to the times of moving.

Cor. Hence the diſtances, and velocities, are not the ſame in every part of the orbit; and there is a Mean Diſtance, and a Mean Motion.

PROP. VI.

If the mean diſtances are divided into 1000 equal parts, the eccentricity of Mercury is 210; of Venus, 7; of the Sun, 17; of the Moon, 55; of Mars, 93; of Jupiter, 48; and, of Saturn, 55.

PROP. VII.

Mercury moves with the mean motion of about 105,000 miles; Venus, of 76,000; the Sun, or the Earth, of 58,000; the Moon, of 2290; Mars, 55,000; Jupiter, of 29,000; and Saturn, of 22,000 miles, every hour.

PROP. VIII.

The motions of the Planets are direct, ſtationary, and retrogade. The motions of the Sun, Moon, and Planets, are explained, both upon the vulgar, and the philoſophical hypotheſis.

PROP. IX.

From the phaſes, light, and every appearance, it is certain, that the Moon, and Planets are opake bodies, which ſhine by reflected light; and, that the Sun, and Fixed Stars ſhine by their own light.

PROP. X.

When the Sun, Moon, or any of the Planets is viewed from the Earth at different times of the year, there is an apparent change of place in the body obſerved, called the annual parallax; which is equal to the difference between the heliocentric, and geocentric longitude.

PROP. XI.

If the plane of the Earth's orbit is taken as a ſtandard, the planes of the orbits of the Moon and Planets are found to be inclined to it, as follows, in round numbers. Mercury, 7°; Venus, $3^\circ\frac{1}{3}$; the Moon, 5°; Mars, 2°; Jupiter, $1^\circ\frac{1}{3}$; Saturn, $2^\circ\frac{1}{2}$.

Of the errors in obſerving the heavenly bodies which ariſe from Refraction. See Optics, Sect. III. IV. V.

PROP. XII.

At the ſame height above the Horizon, the refraction of the heavenly bodies is the ſame; and it produces no error at the Zenith. It is greateſt at the Horizon, becauſe the rays fall with the greateſt obliquity upon the ſpherical ſurface of the atmoſphere, paſs through the longeſt ſpace of vapours, and through the groſſeſt vapours. It varies likewiſe, according to the ſtate of the weather.

Cor. Hence the different appearances which the heavenly bodies have at the Horizon, and Zenith;

in winter, and ſummer; on vallies, and hills; and in different climates. And, hence the uſe of a barometer, and thermometer, and of a table of refractions, when aſtronomical obſervations are made.

SECT. V.

OF THE DAY, NIGHT, AND SEASONS, OF THE EARTH.

PROP. I.

When, in a dark room, the rays of a luminous body fall upon an opake globe, and form a Great Circle of illumination and darkneſs upon it; the illumined hemiſphere is next to the luminous body.

PROP. II.

If the globe is at reſt in the centre of a circular orbit, and the luminous body is carried equably round it, the circle of illumination will ſhift continually, and every part of the globe will be once in the light, and darkneſs. If the luminous body is at reſt, and the globe revolves upon its axis, and continues in the centre of the orbit, the ſame effects will follow.

PROP. III.

While the axis of the globe is at right angles to the plane in which the bodies are, the circle of illumination will paſs continually from pole to pole: While it is not at right angles, the circle of illumination will not paſs through the poles, but through different points, according to the obliquity of the angle.

PROP. IV.

Let the luminous body be placed in the centre of the orbit, let the globe be placed in the circumference, let its axis make an angle of 23°½, with a perpendicular to the plane of the orbit, and, while it revolves upon its axis, let it be carried round equably in the orbit, with the axis always parallel to itſelf; and then, the circle of illumination will paſs from pole to pole at two points in the orbit; and, at the middle of theſe periods, the poles will be alternately, and for a long time, within the the circles of illumination, and of darkneſs.

PROP. V.

Aſtronomers find that the pole of the Earth makes, with a perpendicular to the plane of the Ecliptic, an angle of 23°½; and that it is always directed to the ſame Fixed Stars nearly; ſo that, conſidering their diſtance, it is nearly parallel to itſelf. They find likewiſe that there is an Equinox on the 20th of March, when the Sun enters Aries; and another on the 23d of September, when he enters Libra; that the longeſt day is on the 21ſt of June, when he enters Cancer, and the ſhorteſt, on the 21ſt of December, when he enters Capricorn; with a regular correſponding increaſe, and diminution, from theſe periods.

PROP. VI.

The above facts ſhew the cauſes of the following phoenomena. The Earth has days, and nights, alternate: They are always of the ſame length under the Equator; and they vary regularly, according to the latitude. There is a Vernal, and Autumnal Equinox; a Summer, and Winter Solſtice. Summer, and Winter are at oppoſite times, in the Northern, and Southern Hemiſphere. The Sun does not ſet for a long time in the Polar Regions. At the end of twelve months, the ſum total of day-light is the ſame in every part of the Earth.

Cor. Hence there is a variety of ſeaſons, and climates, which is increaſed by the circumſtances enumerated in Somatiology, Sect. XII. Prop. LXII.—LXX.; while the darkneſs of the long nights in the Polar Regions, is diminiſhed by the dawn, twilight, ſky ſtreamers, reflection of light from the ſnow, and the long continuance of Moon light.

PROP. VII.

By the eccentricity of the Earth's orbit, with the Sun in the focus, ſhe is 2754000 miles nearer to him in December than in June; but, there are two reaſons why the heat of the Earth is not greateſt when his diſtance is leaſt. The eccentricity is only as 17 to 1000; and therefore, it occaſions a ſmall difference in the ſpiſſitude, or number of rays. The quantity that falls is much greater in ſummer than in winter, on account of the length of the days; and even that quantity is diminiſhed at the ſurface of the Earth, by their greater obliquity in Winter.

SECT. VI.

OF THE DISCS, PHASES, ECLIPSES, &C. OF THE SUN, AND MOON; AND TRANSITS OF MERCURY AND VENUS.

PROP. I.

When a globe, and a circular plane, of the ſame colour, and diameter are placed at right angles to the eye of a ſpectator, and at a conſiderable diſtance from him, both of them have the ſame circular, flat, appearance.

PROP. II.

If a luminous globe, and an opake globe are placed in a dark room, there is a ſhadow behind the opake globe, which is always a circle: if they are of equal diameters, the ſhadow is a cylinder: if the opake globe is largeſt, the ſhadow is a cone with the apex towards the luminous globe: if the luminous globe is largeſt, the cone is inverted.

PROP. III.

Around that opake globe as a centre, let another one of the fourth part of its diameter be carried in an orbit, the diameter of which is the eighth or tenth part of the other, and inclined to it at 5°; let it complete 13 periods, while the other completes one; and let it revolve once upon its own axis during its own period; and then, The ſmall globe will intercept the light which falls upon the large one, and the large globe will intercept the light which falls upon the ſmall one, as often as they are in a plane that is common to all the three: The ſame ſide of the ſmall globe will always be turned to the large one: The times, and quantities of the deficiencies of light may be calculated by knowing the bulks of the globes, their periods, the diameter of their orbits, and the poſition of the line made by the interſection of the planes of their orbits.

Theſe experiments, with proper illuſtrations, explain the facts which are contained in the next five Propoſitions, to wit,

PROP. IV.

That the Sun has no phaſes like the Moon: that the Moon revolves upon her axis in the ſame time nearly that ſhe completes her period: that there is an eclipſe of the Sun when the Moon obſtructs the Sun's rays, ſo that they cannot reach to a ſpectator on the Earth; and an eclipſe of the Moon, when the Earth obſtructs the rays of the Sun, which, without that obſtruction, would illumine the Moon: that there is a Total Eclipſe of the Sun when he appears to be entirely covered by the Moon, her apparent diameter being greater than that of the Sun: that there is an Annular Eclipſe when the Sun's diſc exceeds the Moon's in every part, and forms round it a luminous ring: that there is a Central Eclipſe when the Moon has no latitude, at the inſtant of apparent conjunction, her centre appearing upon the centre of the Sun; and the eclipſe is total, or annular, while it is central: that when it is not total, the diſc is ſuppoſed to be divided into twelve equal parts called digits, by which the quantity of the eclipſe is meaſured.

PROP. V.

That if the orbit of the Moon was in the Ecliptic, there would be eclipſes at every conjunction and oppoſition; but, it being inclined at about 5°, and cutting the Ecliptic at two points, called the Nodes, there can be no eclipſes but when the Sun is near them, and ſo near the Ecliptic as to cover the Sun, or to enter into the ſhadow of the Earth, which, as well as the body of the Sun, is always in the Ecliptic.

Cor. There can be no eclipſe of the Sun, but at the time of New Moon; and no eclipſe of the Moon, but at the time of Full Moon.

PROP. VI.

That in the greateſt eclipſe of the Sun, at any time and place, the total darkneſs continues no longer than when the Moon is moving in her orbit 1′, 38″ from the Sun, which is about 3′, 13″ of time: that about 180 miles is all the ſurface of the Earth that is in the dark ſhadow when the Moon's diameter is greateſt, and the Sun's leaſt; but, that there is a faint ſhadow called the Penumbra, which may cover 4900 miles, within which the Sun is ſaid to be eclipſed, and more or leſs, according to the diſtance of the place from the centre of the Penumbra: that when the Moon changes exactly in the Node, the Penumbra is circular at the middle of the general eclipſe, but that, at every other time, it is elliptical, and more or leſs ſo, as the time is longer before, or after the middle of the eclipſe: that the beginning and end of an eclipſe at any place, is meaſured by the contact and departure of the Penumbra: that its longeſt continuance is 5 hours, 50′, at a mean rate, when the Moon is neareſt to the Earth, but that it is longer when ſhe is at her greateſt diſtance: that the Moon, when totally eclipſed, is not inviſible, but dark, like tarniſhed copper, owing to ſome of the Sun's ray's, which are inflected into the Earth's ſhadow, by going through the atmoſphere: that when the Moon is a few days old, ſhe is ſeen, in clear weather, with her luminous creſcent embracing the reſt of the Moon's diſc, which is made viſible by a faint light reflected from the Earth.

PROP. VII.

That the eclipſes of the Sun are more frequent than thoſe of the Moon; but, that there are more viſible eclipſes of the Moon; that the whole number of ſolar and lunar eclipſes in one year, cannot be leſs than two, nor more than ſeven: That when the Sun, Moon, and Nodes have been in one line of conjunction, they return to nearly the ſame ſtate, after 223 lunations, which make 18 Julian years, 11 D. 7 H. 43′, 20″; the laſt day of February in the leap years being four times included.

PROP. VIII.

That in order to calculate an eclipſe, it is neceſſary to have the time of the conjunction, or oppoſition, the latitude of the Moon for the moment of the conjunction, the motion of the Moon in longitude and latitude, the parallax, and the diameters of the Sun and Moon: that it is more difficult to calculate the eclipſes of the Sun than of the Moon, becauſe the parallax differs from every part of the Earth; whereas the eclipſes of the Moon are exactly the ſame wherever they are ſeen.

PROP. IX.

When the beginning and end of an eclipſe can be obſerved in different places of the Earth; or, when the time of the ſame conjunction at each of the places can be found, the difference of the time is that of the meridians, or the longitude; an hour being allowed to 15°, and ſo in proportion.

PROP. X.

If the diſtance of the Moon from any Fixed Star, together with the exact time, is obſerved at Sea; and, if the time when it has the ſame diſtance is computed for the firſt meridian; the difference between the computed time, and the obſerved time, will give the longitude, as if it had been found by an eclipſe; and lunar tables are now ſo accurate, that the place of the Moon may be determined in any part of her orbit, to within leſs than a minute of the truth.

PROP. XI.

There are Inequalities in the Moon's motion; but errors that are known ceaſe to be ſuch. 1. The Equation of her Orbit, which is ſometimes 5°, and ſometimes $7^{\circ}\frac{1}{3}$, according to the ſituation of the Sun with reſpect to her. 2. The Evectio, which depends upon the double diſtance of the Sun. 3. The Variation which is $37'$, but is nothing at the New and Full Moons, and Quadratures. 4. The Annual Equation, which is $11'\frac{1}{4}$. 5. The Acceleration of her mean motion, by which it appears that the lunar month is leſs than it was 2000 years ago.

PROP. XII.

When there is a paſſage of Mercury, and of Venus over the Sun, they appear to be dark round ſpots; Mercury covering one hundred and thirty parts, and Venus, the thirtieth part of his diſc. When theſe paſſages are accurately obſerved, at different places, they give the means of determining the parallax of the Sun, and ſo give the diſtance of all the Planets among themſelves, and with regard to the Earth. There are the following advantages in obſerving the paſſage of Venus. The great preciſion with which the contact of a luminous and a dark object can be obſerved. The known ratio of the parallax of Venus to the Sun, with that of all the other Planets. The greatneſs of the parallax which makes more than a quarter of an hour of difference between the obſervations, and which is more than double that of the Sun.

SECT. VII.

OF THE ASTRONOMICAL MEASURES OF TIME.

PROP. I.

The nature of Abſolute, and Relative Time was conſidered in Somatiology, Sect. 1. Aſtronomers call Abſolute Time by the term, Mean Time, Equal Time, or True Time; and they call Relative Time, Apparent Time, or Common Time. The artificial meaſures of Mean Time were explained in Mechanics, Sect. xx. The natural meaſures, which belong to Aſtronomy, are a year, a month, a week, a day, a night; with their diviſions, and ſubdiviſions.

PROP. II.

There is a difference betwixt Mean and Apparent Time, as meaſured by the Sun, which is cauſed by the Obliquity of the Ecliptic, and by the unequable motion of the Sun. By the firſt cauſe, the Sun, except at the Equinoxes and Solſtices, does not return to the meridian at the ſame time with a Fixed Star. See Sect. 1. Prop. 1.: And, by the ſecond cauſe, they could never be found together, but when the Sun is in the Apogee, and Perigee. The firſt cauſe ſhortens the natural days moſt in March and September, and lengthens them in December and June. The ſecond, lengthens them moſt in December, and ſhortens them moſt in June; and, when both concur in lengthening them, they muſt then be longeſt. Both cauſes operate contrary ways in June, but the firſt lengthens the natural day more than the ſecond. In November, there is a difference of 16′, 9″, between Apparent Time, and True Time; and there are Tables of Equation by which the difference may be found for every day of the year.

Cor. A Sun Dial marks the time in ſuch a manner that every hour is the twenty-fourth part of the time between noon, and noon; and, as the natural days, meaſured by the Sun, are unequal, the hours meaſured by a Sun Dial muſt be ſo likewiſe; that is, of different lengths at different times of the year, though the difference cannot be ſeen in common Sun Dials.

PROP. III.

In the Year of ancient Rome, there was great irregularity, till Julius Caeſar ordered that, in every fourth year, the elapſed quarters of a day, ſee Sect. IV. Prop. I. ſhould be accounted for, by inſerting for them one whole day between the 23d and 24th of January; and becauſe the 23d of February was called Sexto Calendas Martii, the intercalated day was called bis ſexto, and the year biſſextile. This, however, was only a partial correction, for the anticipation of 11′ in a year amounted, in 130 years, to a whole day; and the Vernal Equinox, which, at the Council of Nice in 325, was on the 21ſt day of

March, was, in 1582, on the 11th day of March. To rectify this, and to bring back the feſtivals to the ſame days of the month, and the months to the ſame ſeaſons of the year, Pope Gregory XIII. ordered ten days, between the 4th and 15th of October, to be ſuppreſſed, the intercalation of a day in February to be continued, the year 1600 to be biſſextile, but three intercalated days to be omitted in every 400 years after that; ſo that the years 1700, 1800, and 1900, ſhould not be biſſextile, but the year 2000; and that this method ſhould be conſtantly obſerved every 400 years. Though this was a very great reformation, it does not entirely remove the error which will amount to about one day in 5000 years. The Gregorian year was received in Britain, inſtead of the Julian, in 1752, by calling the 3d of September the 14th; and, in England, the beginning of the year was then changed from the the 25th of March to the 1ſt of January.

PROP. IV.

The Moon was uſed, and ſtill is uſed, as a meaſure of time in moſt nations; and the confuſion which it produced was inextricable, from the nature of her periods, the difficulty of aſcertaining them, and the intercalation of days, on account of public feſtivals. The year, and month of the ancient Jews, and Greeks, were adjuſted to each other with great want of preciſion. The Jews, for inſtance, did not call that day the New Moon, or the firſt day of the month, in which the Moon was in conjunction with the Sun, but the day after the conjunction, when the New Moon firſt appeared in the evening. And, when ſhe could not be ſeen in proper time, the thirty firſt day was declared to be the New Moon. This was not all, they often made an intercalation of ſeveral days, and ſometimes even of a whole month, in order to accommodate the year to ſtated feſtivals, and unexpected events.

Of lunar months, and years, in other nations. Of nights, days, and hours, and their diviſions. Of the adjuſtment of time by Golden Numbers, Dominical Letters, Epacts, and Cycles of the Moon.

Of the Calendar, Almanack, and Ephemeris.

SECT. VIII.

OF THE COMETS.

PROP. I.

The number of Comets which belong to the Solar Syſtem is unknown. About 460 are mentioned by different authors, many of which may be the ſame returning again. It is probable that a great number are not mentioned at all; becauſe, though the Pythagoreans had juſt notions concerning Comets; yet, from the time of Ariſtotle, to that of Tycho Brache, it was the common opinion that they were only temporary meteors, the forerunners of political events. Accordingly, of the above number, there are not more than 60 which have been obſerved with aſtronomical care.

PROP. II.

Comets move in paths which are very eccentric ellipſes, with the Sun in the focus; and which ly in every direction. They deſcribe areas proportional to the times. They generally have, when firſt ſeen, a hazy appearance; but, as they approach the Sun, they acquire a thin light, in ſhape like a head of hair, and which is always turned from the Sun. Some of them gave a light that was compared to a third part of the Moon's, that extended to ſeventy degrees, and that was bright for ſix months. Many, however, had no haze, nor tail; but were round and bright, like Jupiter, or Venus.

They are opake bodies like Planets, and their Elements, or the articles which determine the ſituation and ſize of their orbits, are, The place of the Node, as if ſeen from the Sun; the Inclination; the place of the Perihelion; the diſtance of the Perihelion; the mean time of the paſſage by the Perihelion; and, the direction of the Comet's motion, which may be either direct, or retrogade.

The cauſe of the Tails is not known. It has been conjectured that they are Light, which is reflected by fine particles evaporated from the Comet, when heated by the Sun; or, that they are ſtreams of electric matter, which iſſue from it, when heated, like a tourmalin. As to their heat, ſee Somatiology, Sect. XII. Prop. LXX.

PROP. III.

Halley's Prediction in 1705, that the Comet which appeared in 1607, and 1682, would appear in 1759, was verified.

PROP. IV.

The Comet which appeared in 1532, and 1661, is expected in 1789, or 1790. The one which appeared in 1264, and 1556, is expected in 1848. The one which appeared in 1680 is expected in 2224; being the ſame which appeared 619 years, and 2349 years before the Chriſtian Æra; and which is ſuppoſed by ſome, to have been the cauſe of the Flood.

SECT. IX.

OF THE DISCOVERIES IN THE HEAVENS BY TELESCOPES.

PROP. I.

Spots are ſeen in the body of the Sun; their number, ſhapes, and bulks, are very different; and they appear, and diſappear, at no regular periods. It has been conjectured that they are maſſes of opake matter, which, by the irregular agitations of the fluid matter of the Sun, ſwim or ſink, like the Scoriae of melted metals; or, that they are Volcanos, like thoſe in the Earth; or, that they are Excavations in the luminous fluid matter, which ſurrounds the body of the Sun. But, whatever is the cauſe of them, they have ſerved to prove, that the Sun revolves upon his axis in 25 days, 14 hours, and 8 minutes; and that his axis is inclined to the Ecliptic, ſo as to make an angle, with a perpendicular to it, of about $7^{\circ}\frac{1}{2}$.

PROP. II.

The ſurface of the Moon has the appearance of vallies, and mountains, the heights of which are known by meaſuring their ſhadows. Her appearance is ſo uniform, that ſhe ſeems not to have the variety of ſnow, and verdure, that is on the Earth; but ſhe has ſimilar volcanos.

PROP. III.

Mercury has all the phaſes of the Moon, except that he is never quite round; for, when his enlightened ſide is towards the Earth, he is ſo near the Sun as to be rendered inviſible by the Sun's rays. It is unknown whether he revolves upon his axis, becauſe no ſpots have been diſcovered on his diſc.

PROP. IV.

When Venus is in different parts of her orbit, ſhe has the phaſes of the Moon; and, by her ſpots, it is known, that ſhe revolves upon her axis in 23 days, and 22 hours.

PROP. V.

Mars is ſometimes gibbous, but never horned like the Moon. He is oblate at the poles, and there are white regions there, which look like ſnow. From the ſpots on his body, it appears, that he revolves upon his axis in 24 hours, and 39 minutes. He ſeems to have an atmoſphere like the Earth. His axis is inclined to the Ecliptic at an angle of 59°, 42′: The Node of his axis is in 17°, 47′ of Piſces. The obliquity of the Ecliptic on his body is 28°, 42′. His equatorial diameter is, to his axis, as 1355 to 1172; or, as 16 to 15 nearly.

PROP. VI.

Jupiter has parallel zones of different colours, called Belts, by which it is known, that he revolves upon his axis in 9 hours, and 56 minutes. He has four Moons, which move in different planes, and revolve upon their axes. They are often eclipſed by going into the ſhadow of Jupiter, and they ſometimes eclipſe each other. Their revolutions and diſtances are as follows.

Jupiter's Satellites.	Periodic Revolutions. D.	H.	M.	S.	Synodic Revolutions. D.	H.	M.	S.	Diſtance in Semi Diam.	Diſt. in Min. in the Mean Diſt. of Jupiter.
Iſt.	1	18	27	33	1	18	28	36	5,965	1′ 51″
IId.	3	13	13	42	3	13	17	54	9,464	2′ 57″
IIId.	7	3	42	33	7	3	59	36	15,141	4′ 42″
IVth.	16	16	32	8	16	18	5	7	26,630	8′ 16″

PROP. VII.

A Satellite is eclipſed about 16 minutes ſooner when the Earth is neareſt to Jupiter than when fartheſt from him. This difference is produced by the time which the Light takes in moving through the diameter of the Earth's orbit, which is 8′, 13″; for, if Light had no motion, or ſuch, that it could not be meaſured, the time of the eclipſes, by calculation and obſervation, would always be the ſame.

Cor. Hence the motion of Light is about a million of times ſwifter than that of a cannon ball. Heavenly bodies may not be ſeen till ſometime after their creation; and, they may appear, as exiſting, after they have ceaſed to exiſt.

PROP. VIII.

When the Satellites enter, and leave, the ſhadow of Jupiter, it is with ſo much diſtinctneſs, that the preciſe time can be eaſily aſcertained. Whereas, the eclipſes of the Moon are not only much ſeldomer, but it is difficult to determine their commencement with preciſion; becauſe the Earth's ſhadow, through which the Moon paſſes, is ill defined.

Cor. Hence the longitude of a place is much better known by the eclipſes of theſe Satellites than by an eclipſe of the Moon. See Sect. VI. And, hence, the importance of conſtructing machines by which they can be obſerved at ſea.

PROP. IX.

There is an Inequality in the Conjunctions, and Eclipſes of Jupiter's Satellites, ariſing from the Inequality of his motion, which ſometimes makes a difference of 11° between two obſervations.

PROP. X.

Saturn has no ſpots, by which it can be determined whether he has any revolution upon his axis. He has five Moons, and a Ring that ſtands off from his body, and which is 23 diameters and a half, when compared to the Earth's, or, more exactly, 23,567; its diameter being 67518 leagues. The edge of the Ring is towards the Planet. Its diſtance from him is nearly equal to its breadth, which is about 21000 miles. The conjecture of ſome has been, that it is a vaſt number of very ſmall Moons diſpoſed in the ſame plane, which, by their blended light, give the appearance of one body. It is inclined to the plane of the Ecliptic at an angle of about 30°, ſo that its appearances are very different, and continually varying.

The firſt Satellite revolves in 1 day, 21 hours, 18′, 27″. The ſecond, in 2 D. 17 H. 44′, 22″. The third, in 4 D. 12 H. 25′, 12″. The fourth in 15 D. 22 H. 34′, 38″. And, the fifth, in 79 D. 7. H. 47′. They ſeem to revolve upon their axes.

Satellites of Saturn.	Longitude in 1760.			Diurnal Motion.				Diſt. in Semi-diam. of the Ring.	Diſt. in Min.&Sec.	
Iſt.	11ˢ.	50°	41′	6ˢ.	10°	41′	51″	2,097	0′	43″½
IId.	9	10	18	4	11	32	5	2,686	0	56
IIId.	4	25	57	2	19	41	25	3,752	1	18
IVth.	0	0	43	0	22	34	37	8,698	3	0
Vth.	7	20	36	0	4	32	18	25,348	8	42½

Of Inequalities in the conjunctions, and eclipſes of theſe Satellites; and in the motion of Saturn.

PROP. XI.

Georgium Sidus is diſtant from the Sun near 19 times farther than the Earth: its magnitude is about 89 times greater, and its period about 82 years.

Of the two Satellites of this Planet.

PROP. XII.

The Fixed Stars were ſuppoſed, even in ancient Greece, to be Suns, with Planets moving round them. By teleſcopes, they are not only increaſed in number, but to an extent that is amazing. They ſeem to ly in ſtratums, and ſyſtems, and to have a general motion in one direction, while they keep their relative diſtances. It is conjectured, therefore, that they move round a great centre, like Planets round the Sun, with inferior ſyſtems of Secondaries, and multitudes of Comets to connect them. But, as Man ſees only a very ſmall part of boundleſs ſpace, there may be many myriads of other ſyſtems diſtinct from them, and placed at ſuch diſtances, that they can never be ſeen in this Earth, even by more perfect teleſcopes than thoſe lately invented, which magnify more than 6000 times.

SECT. X.

OF THE CENTRAL FORCES OF THE HEAVENLY BODIES.

PROP. I.

It has been found, by the moſt accurate obſervations, that the Planets move in paths which are ellipſes: That the Sun is placed in the focus of each of their orbits: That they deſcribe round him areas proportional to the times: And, that the ſquares of the periodic times are proportional to the cubes of the mean diſtances.

PROP. II.

The ſecondary Planets move by the ſame laws, with regard to their Primaries; and, the more exactly the times, and diſtances are taken, the more exact are theſe mathematical proportions.

PROP. III.

Comets move in paths which are very eccentric ellipſes, with the Sun in one of the foci; and the areas which they deſcribe are as the times.

Cor. 1. Hence the Planets ſeem to be retained in their orbits by a force directed to the Sun; and which is inverſely proportional to the ſquares of their diſtances from him.

Cor. 2. The Secondaries ſeem to be retained in their orbits round their reſpective Primaries, by forces directed to them, and according to the ſame law; while they, in the ſame manner, accompany their Primaries by a force directed to the Sun.

Cor. 3. This force ſeems to be mutual between the Planets and the Sun; and between the Secondaries and their Primaries.

Cor. 4. From theſe Facts, and thoſe contained in Mechanics, Sect. vii. it is manifeſt, that if the power of gravity acts upon all the matter in the ſolar ſyſtem, and, if certain projectile forces were originally impreſſed upon the Planets, Secondaries, and Comets, the combination of theſe two powers may have formed one Cauſe, which is ſufficient to produce all the motions of theſe bodies.

SECT. XI.

OF THE ANOMALIES OF THE FIXED STARS.

PROP. I.

About 200 years before the Chriſtian Æra, the obliquity of the Ecliptic was 23°, 50′. In the year 880, it was 23°, 35′. In 1587, it was 23°, 31′, 30″. And in 1787, it is 23°, 28′; ſo that it diminiſhes about one minute every 100 years.

PROP. II.

There is a change in the longitude of all the Fixed Stars, called the Preceſſion of the Equinoxes. It is a retrogradation of the Equinoctial Points, at the rate of about 50″$\frac{1}{3}$ every year; in conſequence of which, the Vernal Equinoctial Point, which, 2000 years ago, was about the middle of Aries, is now about the middle of Piſces; the ſecond ſign is called Taurus, though in the conſtellation Aries; and ſo of the reſt; while the ſigns keep their ancient names.

PROP. III.

The Fixed Stars have a motion of 9″, the period of which is 18 years. It is called the Nutation.

PROP. IV.

An aberration of the Fixed Stars has been diſcovered, by which they ſeem to deſcribe an ellipſe of 40″ in diameter.

PROP. V.

Though an annual parallax is eaſily obſerved in the Planets, it is ſo difficult to be aſcertained in the Fixed Stars, that to ſome it appears to be doubtful.

PROP. VI.

A proper motion has been obſerved in ſome of the Fixed Stars. Thus, between the year 1690 and 1750, there was a difference in the place of Arcturus of 19′, 21″, which ſhould have been only 17′, $7''\frac{2}{3}$, by the known laws of the Preceſſion of the Equinoxes; and Sirius, Aldebaran, and Rigel ſeem to have had proper motions likewiſe.

Scholium. The above anomalies of the Fixed Stars, may ariſe from the ſame cauſes which are enumerated in the laſt four corollaries. Thus, the diminution of the obliquity of the Ecliptic may be the effect of Jupiter's attraction. The preceſſion of the Equinoxes, the effect of the Sun and Moon's acting with greateſt force upon the equatorial parts of the Earth, which is an oblate ſpheroid. The Nutation, the effect of the attraction of the Moon upon the Earth, as diſtinguiſhed from her attraction when co-operating with the Sun, in producing the Preceſſion of the Equinoxes. The Aberration, the effect of the motion of light combined with the annual motion of the Earth. The annual parallax of the Fixed Stars is doubtful, on account of their immenſe diſtance, their unequal diſtances, or their unequal magnitudes. The proper motion of ſome of the Fixed Stars may be the effect of ſome unknown cauſe, which is not inconſiſtent with gravity, and a projectile force; or, it may have been produced by Comets, the paths of which are unknown.

SECT. XII.

OF SYSTEMS IN ASTRONOMY.

PROP. I.

By the Ptolemaic Syſtem, which is that of the

Vulgar, with the addition of many fictions, the Earth is ſuppoſed to be immoveable in the centre, and the heavenly bodies to move round her in this order; the Moon, Mercury, Venus, the Sun, Mars, Jupiter, Saturn, the Firmament of the Fixed Stars, the firſt Cryſtalline Heaven, the ſecond Cryſtalline Heaven, the Primum Mobile, and the Coelum Empyraeum. Theſe orbs are ſuppoſed to move round the Earth once in twenty-four hours, and likewiſe at certain periods. Every Star is ſuppoſed to be fixed in a ſolid tranſparent ſphere like cryſtal; and a great number of circles, called Eccentrics, Cycles, and Epicycles, are ſuppoſed to interſect each other in all directions, and to produce the different motions.

PROP. II.

The Syſtem called the Egyptian, ſuppoſes the Earth to be at reſt in the centre of the orbits of the Moon, of the Sun, Mars, Jupiter, and Saturn; but, that the Sun is in the centre of the orbits of Mercury and Venus.

PROP. III.

In Tycho Brache's Syſtem, the Earth is ſuppoſed to have no motion, and to be the centre of the orbits of the Moon and Sun, while the Sun is the centre of the orbits of Mercury, Venus, Mars, Jupiter, and Saturn.

PROP. IV.

The Semi-Tychonic Aſtronomers ſuppoſed the Earth to revolve every twenty-four hours upon her axis; but, they maintained the other parts of Tycho Brache's Syſtem.

PROP. V.

In the Copernican, or Pythagorean Syſtem, as enlarged by late diſcoveries, the Sun is ſuppoſed to have no motion but upon his own axis; and to be in the focus of the elliptical orbits of Mercury, Venus, the Earth, Mars, Jupiter, and Saturn, which move round him from weſt to eaſt, as in Sect. I. Prop. IV.; the Earth's motion is ſuppoſed to be the ſame as the apparent motion of the Sun, while ſhe revolves upon her own axis every 24 hours, and is in the focus of the Moon's orbit; the Satellites are ſuppoſed to revolve as in Sect. IX.; with the other phoenomena relating to them, and the Fixed Stars. The motions of the Planets, Secondaries, and Comets are ſuppoſed to be the effect of the power of gravity, combined with a projectile force, originally impreſſed, as explained in Mechanics, Sect. VII.

SECT. XIII.

OF THE TRUTH OF THE COPERNICAN SYSTEM.

PROP. I.

There are only three objections to the Copernican Syſtem, which deſerve attention.

1. Our perceiving no motion in the Earth, and our ſeeing the diurnal, and proper motion of the heavenly bodies. 2. The return of a body to the ſame place, when thrown up at right angles to the Horizon. The ſtriking of a ſtone at the foot of a ſteeple, when it falls from its top. A cannon ball's having the ſame momentum, when ſhot from the

eaſt, and from the weſt, with equal charges. 3. Expreſſions in the Sacred Books, which are not agreeable to the truth of this Syſtem.

The firſt of theſe objections is fully anſwered by the unperceived motion of a boat that glides ſmoothly along; and by the apparent motion of immoveable objects to the people that are in her, as explained by the laws of Optics. The ſecond is founded upon a total ignorance of facts relating to the motion of bodies. See Mechanics, Sect. 1. The third is equally ineffectual, and for the following reaſons. The Sacred Writers uſed the common modes of ſpeaking, and with great wiſdom. They uſed expreſſions concerning the Earth, and the heavenly bodies, which might be brought, with equal juſtice, to prove the moſt exceptionable parts of the Copernican Syſtem. They do not ſay, that they deliver a Syſtem of Aſtronomy, Agriculture, Mechanics, &c.; the things relating to them being only mentioned occaſionally. Theſe books were written, not to inſtruct men in the arts and ſciences; but, profeſſedly, as an authoritative promulgation of things of much more importance, which could never have been diſcovered by all the reſearches of the moſt acute Philoſophers.

The facts, therefore, contained in theſe three objections, neither prove, nor diſprove, the truth of this Syſtem, nor of any other Syſtem; while, by the third objection, an attempt is, unthinkingly, made to degrade the Sacred Writings.

PROP. II.

The evidence for the truth of the Copernican Syſtem, is either Probable, or Demonſtrative; it being remembered, that the firſt is not abſolutely concluſive, on account of our ignorance; and that the ſecond is a proof of facts in the material world, not of the relations of our ideas, which is a ſpecies of evidence, as in Mathematics, that can never be obtained for facts, either in common life, or in Aſtronomy.

PROP. III.

The Probable Arguments reſt upon the likelihood of the ſame cauſes being extended to the heavens, which exiſt upon the Earth, in order to produce ſimilar motions; upon their ſimplicity; upon their wiſe adjuſtment; upon the elevated ideas which they give of the univerſe, and its Author; and, upon the inſufficiency of the hypotheſes made by Ptolemy, Des Cartes, and others, to account for the phoenomena.

PROP. IV.

The Demonſtrative Proofs may be conſidered under the following heads.

Mercury and Venus have two conjunctions, and no oppoſitions. Mars, Jupiter, and Saturn have their conjunctions, and oppoſitions, alternate, and ſucceſſive. The greateſt elongation of Mercury is about 20°, and of Venus about 47°. The ſplendor, and diameters, of Venus, and Mars, are very unequal in the different parts of their orbits. They have different phaſes. The Planets are direct, retrogade, and ſtationary. Mercury, and Venus, in their lower conjunctions, are hid beyond the body of the Sun; and, in their upper conjunctions, paſs over it. The Light of Jupiter's Moons, reaches the Earth ſooner at one time of the year, than at another. The aberration of the Fixed Stars. The eccentric motions of the Comets to vaſt diſtances, and in all directions.

The oblate figure of the Earth. The unequal vibrations of the ſame pendulum in different latitudes. The attraction of plummets by mountains. The return of bodies to the Earth, when thrown vertically, from the higheſt mountains. The decreaſe of gravity, as the ſquares of the diſtances. The tides of the ocean. The law of the heavenly bodies, by which the areas deſcribed are as the times of moving, and the ſquares of the periodic times as the cubes of the diſtances. The elliptical figure of the orbit of the Moon round the Earth, of the Satellites round their Primaries, and of all the Planets, and Comets round the Sun. The Preceſſion of the Equinoxes. The Nutation of the Earth's axis. The Inequalities of a Comet in 1759, the laſt revolution of which was 585 days longer than the preceding, as foretold by Aſtronomers, from a calculation of the attractions of Jupiter, and Saturn. The oblate figure of Jupiter and Mars. The change of the latitude, and longitude, of the Fixed Stars. The diminution of the obliquity of the Ecliptic. The motion of the Apogee of the Moon, and of the Apſides of the Planets. The motion of the Nodes of the Moon, and of the Nodes of all the Planets. The Inequalities of Jupiter's Satellites.

After theſe proofs have been examined ſingly, they muſt be placed in one view; becauſe the proper evidence of every fact, conſiſts in the union of all the proofs, or in the reſult of their relations to each other: And, that perſon muſt be unable to underſtand them, who does not ſee that they demonſtrate the truth of the Copernican Syſtem, in the cleareſt manner.

CONCLUSION.

A General Survey of Matter, and its laws, from its minuteſt particles, to its greateſt, and moſt diſtant maſſes; from which it appears, that it is inert, and that it is conſtantly governed by a Power that is immaterial, intellectual, wiſe, and powerful, to a degree which exceeds the conception of the human mind; and which, when compared to human powers, may be greater than all the matter in the univerſe, compared to a ſingle atom.

An account of the ſentiments of high veneration which have been expreſſed, by the intelligent Natural Philoſophers of all ages, for the Omnipotent, and the All-perfect Being.

Docenti cuique ſuo utendum judicio, ſua arridet methodus, docendi ratio, rerum ſeries, argumentorumque momenta, quae diſcentium ingeniis, ut juvenum captus eſt, optimè accommodata, atque ad ſenſus penitùs permanantia, ſibi videntur. Quumque noſtra methodus, iſtis quae nuper invaluerunt, non paullum diſcrepet; ſi quid ea afferat quod diſcipulis prodeſſe poteſt, eorum intererit, breve aliquod in manibus terere ſyntagma, quod rerum ſeriem, ſummaque diſputationum capita exhibeat; ipſiſque omnia vivâ voce fuſius explicata, in memoriam revocet. H. I. C. P. M.